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UPPER HUMBER RIVER WATER QUALITY STUDY

TECHNICAL REPORT # 8

A REPORT
OF THE

TORONTO AREA WATERSHED
MANAGEMENT STRATEGY
STEERING COMMITTEE

April, 1986

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Municipality of Metropolitan Toronto
Borough of East York
City of Etobicoke
City of North York
City of Scarborough
City of Toronto
City of York
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Regional Municipality of York
Environment Canada

UPPER HUMBER RIVER
WATER QUALITY STUDY

TECHNICAL REPORT #8

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TORONTO AREA WATERSHED
MANAGEMENT STRATEGY
STEERING COMMITTEE

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December, 1985

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The study benefited from the input of an Advisory Committee comprised of representatives from the MOE, the Ministry of Natural Resources, the Ministry of Agriculture and Food, Peel and York Regional Health Units and the MTRCA. The study was funded by a grant to the MTRCA administered by the MOE, Water Resources Branch.

EXECUTIVE SUMMARY

As a result of detailed pollution studies on the lower Humber River from 1982-83 as part of the Toronto Area Watershed Management Strategy Study (TAWMS) it became apparent that violations of the Ministry of the Environment's (MOE) Provincial Water Quality Objectives (PWQO) in the Humber River occurred north of the Metropolitan Toronto boundary. Therefore in order to address the TAWMS objective of restoring water quality to PWQO, the incorporation of corrective measures in the Humber River north of Steeles Avenue was deemed necessary as part of the overall strategy. Specifically, exceedances of fecal coliform bacteria (FC), total phosphorus (TP), total suspended solids (TSS), lead (Pb), cadmium (Cd) and copper (Cu) were of concern.

Accordingly, in 1984 the MTRCA received a grant from the MOE to undertake a water quality study in the Upper Humber watershed. The general objective was to identify in more detail the sources of selected chemical and microbiological pollutants in the Upper Humber.

The study consisted of:

- a mapping exercise to identify areas of potentially high overland sediment delivery in rural areas of the watershed using an adaptation of the Universal Soil Loss Equation.
- a series of dry and wet weather surface water sampling surveys (Synoptic Survey, Dry Events 1-3, Wet Event) and a bed sediment sampling survey, both aimed at evaluating the contaminant contributions of Upper Humber subbasins.
- a field inventory to identify land use problems (eg. livestock access), point source inflows and stream bank erosion sites impacting on watercourses in the Upper Humber watershed.

Microbiological sampling indicated widespread water quality degradation throughout the Upper Humber watershed. Fecal coliform counts regularly exceeded the PWQO at most sampling stations. Exceedances were most pronounced during wet weather. Generally, wet weather FC exceedances on the West Humber and East Humber Rivers were greater than those on the Humber River.

Fecal pollution in the Upper Humber watershed originates from a combination of rural and urban sources. Even in the relatively undeveloped upper reaches of the watershed FC exceedances were commonplace. For example, at station H-20, located north of Highway 9 less than 10 km from the source of the Humber River, the PWQO was exceeded. Indications are that, although an area may be largely undeveloped, significant local problems may still exist.

The towns of Bolton and Woodbridge provide good examples of the effects of local urbanization in the watershed. Within both communities there were numerous point sources, some of which were shown to be potentially significant dry weather sources of fecal pollution. Fecal coliform counts regularly increased through the towns.

During the Synoptic Survey and Dry Event sampling the frequency and degree of TSS and TP exceedances were greatest in the Humber River subbasins between Bolton and Woodbridge. As well, these same subbasins (i.e. H-11, H-14, H-15) contributed the greatest dry weather loadings of TSS. These subbasins likewise had significant loadings of TP, however, large increases in TP loading also occurred upstream within the town of Bolton (i.e. subbasin H-9). Total suspended solids and TP increases between Bolton and Woodbridge may relate in part to the observed stream bank erosion and livestock access problems in this area. Wet weather TSS and TP exceedances were more widespread. Mean exceedance ratios were higher in wet than in dry weather.

Copper concentrations usually exceed PWQO throughout the watershed except during Dry Event 3. Lead concentrations rarely exceed PWQO during Dry Events 1 and 3, however, in Dry Event 2, widespread Pb exceedances occurred. During wet weather conditions Pb concentrations increased slightly and exceedances were more common.

In contrast to trends noted for TSS and TP, spatial and weather-related differences in Cu and Pb concentrations were minimal. These results corroborate other studies which indicate that significant inputs of Cu and Pb to watercourses can occur from diffuse atmospheric sources (precipitation and dry fallout) (Demayo et al. 1980, Demayo and Taylor 1981). One possible exception to this was subbasin E-8 which may be a source of Cu and Pb. The bed sediment sample from station E-8 had comparatively high concentrations of Cu and Pb as well as the highest observed zinc concentration.

Cadmium exceedances occurred at over three-quarters of the sampling stations in in Dry Event 2. No exceedances occurred during Dry Event 3. Cadmium concentrations differed from those of Cu and Pb in that they were slightly less uniform throughout the study area and they increased dramatically under wet conditions. This suggests that Cd inputs to the watercourses occur primarily from localized overland sources and are facilitated by storm event runoff.

The significance of the West Humber's unique drainage basin topography was apparent during event sampling. In summary dry weather, the West Humber River had greatly reduced or intermittent flow; a tributary, "Gore Creek", contributed a major portion of the system's discharge. In response to the prolonged rainfall of the Wet Event, flow in the West Humber River became torrential, with peak discharge rivalling that of the Humber River at Woodbridge. During the Wet Event, subbasin W-6 became the major discharge and contaminant contributor.

As with subbasin W-6, the H-17 subbasin took on greater importance in the Wet Event. During the Wet Event, discharge and chemical loadings of the Humber River increased approximately 30% through subbasin H-17. This subbasin exhibited no loading increases of this magnitude in any of the other events. The reason for subbasin H-17's increased importance in the Wet Event may stem from a combination of factors related to the degree of soil impermeability and the extent of urban land use. Other subbasins (eg. E-8 on the East Humber River) are likewise influenced by urbanization.

The great disparity between dry and wet weather outputs of the West Humber drainage basin becomes significant when attempting to assess the relative impacts of the West Humber, Humber and East Humber Rivers on the lower Humber. Although the effects of Claireville Reservoir are not fully known, it is apparent that the relative impact of the West Humber River on the lower Humber would be greater under wet as opposed to dry conditions.

The decreased chemical and microbiological concentrations in Dry Event 3 may indicate that the importance of contaminant sources varies with season. The late fall and winter months are characterized by reduced or absent livestock pasturing, crop tillage and construction, frozen soils and stream banks less susceptible to wind and water erosion, and precipitation which, instead of running off, is stored on the land as snow until spring. All of these would combine to reduce contaminant inputs to watercourses during this season. Seasonal factors also affect the evaluation of the Soil Loss Mapping. Results did not correspond well with observed subbasin loadings, due to the significant contribution of overland sediment inputs during spring runoff, a period not sampled in this study.

A number of recommendations resulted from this study, most importantly, that water quality problems in the Upper Humber watershed, although not of the magnitude of those occurring in the lower Humber River, cannot be discounted in the development of a water management strategy if PWQO are to be achieved. The implementation of pollution control measures in the Upper Humber watershed and the achievement of at least local PWQO compliance would be less costly than the initiation of control options for the lower Humber River.

The study identified that water quality problems in the Upper Humber watershed result in significant localized water quality degradation. Of particular concern is the loss of public swimming facilities at Claireville Reservoir (West Humber River) and Boyd Conservation Area (East Humber River) due to fecal contamination. It is suspected that these water quality problems could be abated through remedial measures such as upsteam livestock fencing and further investigation and correction of point source problems. It is suggested that the MTRCA coordinate such an abatement program with MOE Central Region, the Ontario Ministry of Agriculture and Food (OMAF) and local municipalities.

The study also identified that a more thorough investigation of the behaviour of non-conservative substances (eg. FC, TP) and of the transport of pollutants by sediment be conducted in the Upper Humber watershed to determine the range of influence of these parameters on the lower Humber River. Pathways (eg. dry atmospheric fallout, precipitation, ground water) by which Cu and Pb enter the Humber River system should be investigated.

More detailed information on the significance of pollutant loadings during spring runoff and under varied storm conditions would aid in assessing the significance of overland sediment inputs. An evaluation of the relative importance of stream bank erosion, livestock access, and identified point sources of contamination to water quality is needed to aid in assessing control measures.

1. INTRODUCTION

1.0 **Introduction**

In 1981 the Ministry of the Environment (MOE) initiated the Toronto Area Watershed Management Strategy Study (TAWMS) in response to concerns expressed by the Metropolitan Toronto and Region Conservation Authority (MTRCA) and its member municipalities regarding the extent of water quality degradation in the watercourses and the lack of information on pollutant sources and remedies.

The purpose of the TAWMS study is to identify pollutant sources within the watersheds and develop a comprehensive water management plan which incorporates cost effective measures for improving water quality, and an implementation strategy which outlines agency responsibilities and time frames for improvement measures.

The five-year study emphasized the Mimico Creek, Humber and Don River watersheds since these typify the wide range of water quality problems experienced by all watersheds within the MTRCA jurisdiction. After an initial screening study in 1981, the TAWMS work schedule was to concentrate first on the Humber River and then develop strategies for the Don River and finally Mimico Creek.

Because of the complexity and greater significance of urban water quality problems and because of funding restraints, the intensive study of the Humber River in 1982 was limited to the watershed area within the Metropolitan Toronto boundaries. The study was again limited to the lower Humber River in 1983 when the resolution of water quality problems along the Metropolitan Toronto waterfront was added to the terms of reference for the TAWMS study.

As a result of detailed pollution studies on the lower Humber River from 1982-83, it became apparent that violations of the MOE's Provincial Water Quality Objectives (PWQO) in the Humber River occurred north of the Metropolitan Toronto boundary. Therefore, in order to address the TAWMS objective of restoring water quality to PWQO, the incorporation of corrective measures in the Humber River north of the Metropolitan Toronto boundary was necessary as part of the overall strategy. Specifically, exceedances of fecal coliform bacteria (FC), total phosphorus (TP), total suspended solids (TSS), lead (Pb), cadmium (Cd) and copper (Cu) were of concern in the upper Humber watershed (TAWMS 1984).

Accordingly, in 1984, the MTRCA submitted a proposal to the MOE and received a grant to undertake a water quality study in the Upper Humber watershed. The specific objectives of this study were as follows:

1. To evaluate the contaminant contributions of Upper Humber River subbasins by sampling surface waters for selected chemical and microbiological parameters in dry and wet weather.

2. To sample the bed sediment of these same subbasins in order to obtain a more historical perspective on contaminant contributions.

3. To map areas of potentially high overland sediment delivery in rural areas of the watershed using an adaptation of the Universal Soil Loss Equation.

4. To identify and describe land use problems (e.g. livestock access), point source inflows and stream bank erosion sites by inventorying watercourses of the Upper Humber River watershed.

In the report, relationships are highlighted between contaminant loadings in the watershed under dry and wet conditions, and problem areas identified during the inventorying and mapping exercises. Exceedances of PWQO are also noted where they occur. Both the frequency and degree of exceedance at each water quality sampling station are identified.

The report concludes with a discussion of the significance of identified problems to the lower Humber River.

2. METHODS

2.1 Study Area

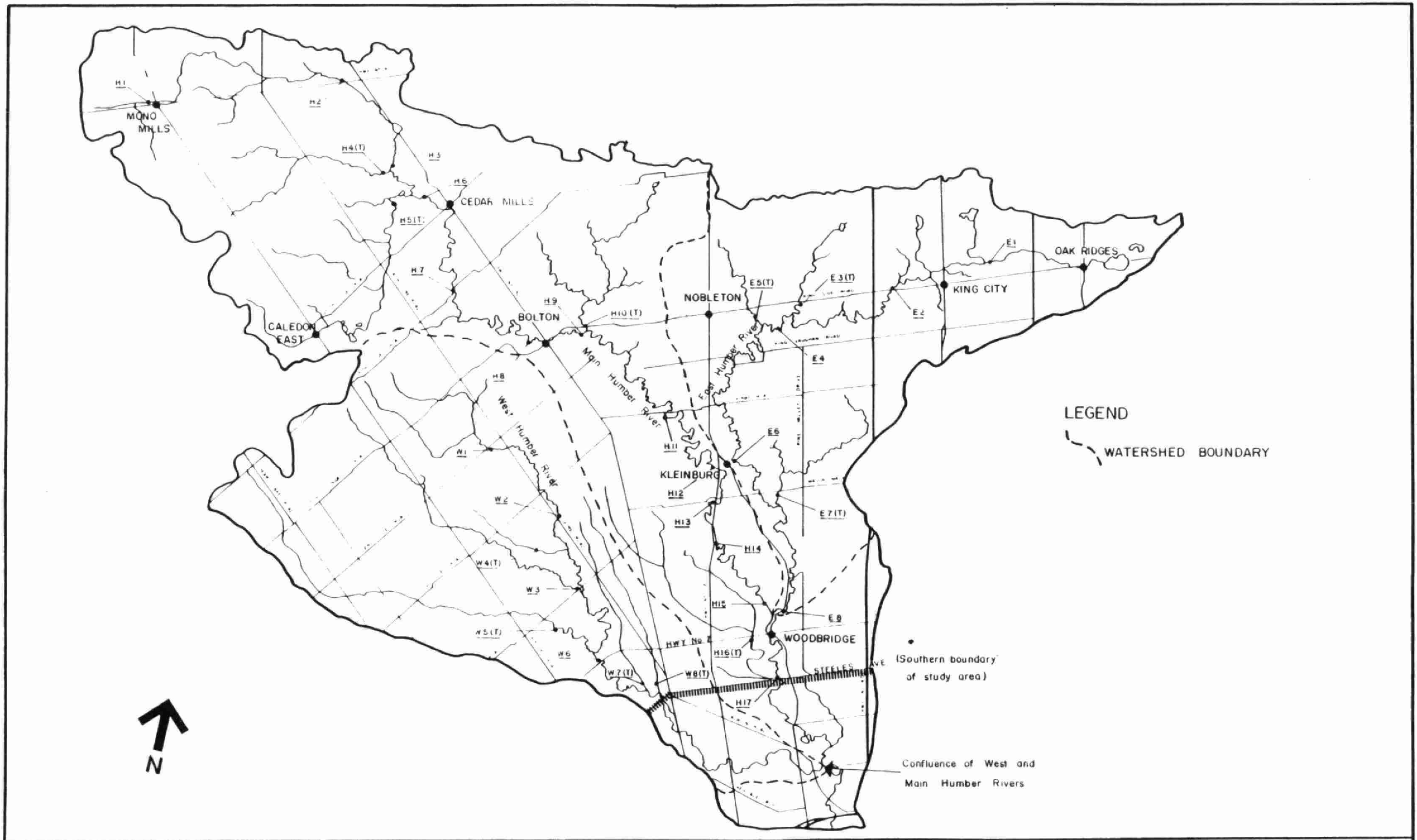
The study area comprises 700 km^2 north of Steeles Avenue, the Metropolitan Toronto boundary (Figure 2.1). The watershed is bounded by the communities of Oak Ridges to the northeast and Mono Mills to the northwest and is formed of three main rivers: the Humber, East and West Humber Rivers. Within the boundaries of the study area the Humber River is the largest of the three with a watershed area of 346 km^2. The East and West Humber Rivers have watershed areas of 190 and 160 km^2 respectively.

The Humber River flows off the Niagara Escarpment and through the hummocky terrain of the Albion Hills. Average stream gradients exceed 1% in the upper areas declining to about 0.25% south of Cedar Mills. Between the town of Bolton and Steeles Avenue the river has cut a broad meandering valley through the glacial till plain.

The East Humber River displays the gentlest stream gradients. From its source at Lake Wilcox the watercourse flows with an average gradient of about 0.20% to its confluence with the Humber River at Woodbridge. The river flows entirely through the soft structured till and Peel clay plains and has carved a very tightly meandering path over its 55 km length.

Relative to the Humber and East Humber Rivers, the West Humber generally exhibits less pronounced valley formation. This is partly due to the impervious, less erodible nature of the Peel clays over which most of the watercourse flows and the fairly level topography of the surrounding tableland. From an initial elevation of about 300 m, the watercourse flows with an average stream gradient of 0.51% to its confluence with the Humber River near Weston Road.

The study area is predominantly rural. The rural component (including areas of open space and forested lands) comprises



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UPPER HUMBER RIVER STUDY

SYNOPTIC SURVEY STATION LOCATIONS

FIGURE: 2.1

MARCH 1985

2 1 0 1 2
km

about 97% of the watershed. Urban development is primarily restricted to several small communities found throughout the study area including Bolton, Nobleton, Woodbridge and Kleinburg.

2.2 Surface Water Quality

To assess the relative pollutant contributions of Upper Humber River subbasins a surface water quality monitoring network was established. Water quality sampling stations were set up at intervals along the Humber, East Humber and West Humber Rivers, and near the mouths of any major tributaries. Land use in the watershed was taken into consideration in the selection of the stations. For example, sampling stations were established to evaluate the effects of agricultural versus forested subbasins. Other stations were located upstream and downstream of urbanized areas such as the towns of Bolton and Woodbridge.

Synoptic Survey

Initially, 30 microbiological and 30 chemical stations (Figure 2.1, Table 2.1) were sampled synoptically to obtain some indication of where problem areas might exist. One sample for chemical analysis was taken from each station on June 20, 1984. Microbiological samples were taken daily from each station from June 20 to 22, 1984 inclusive.

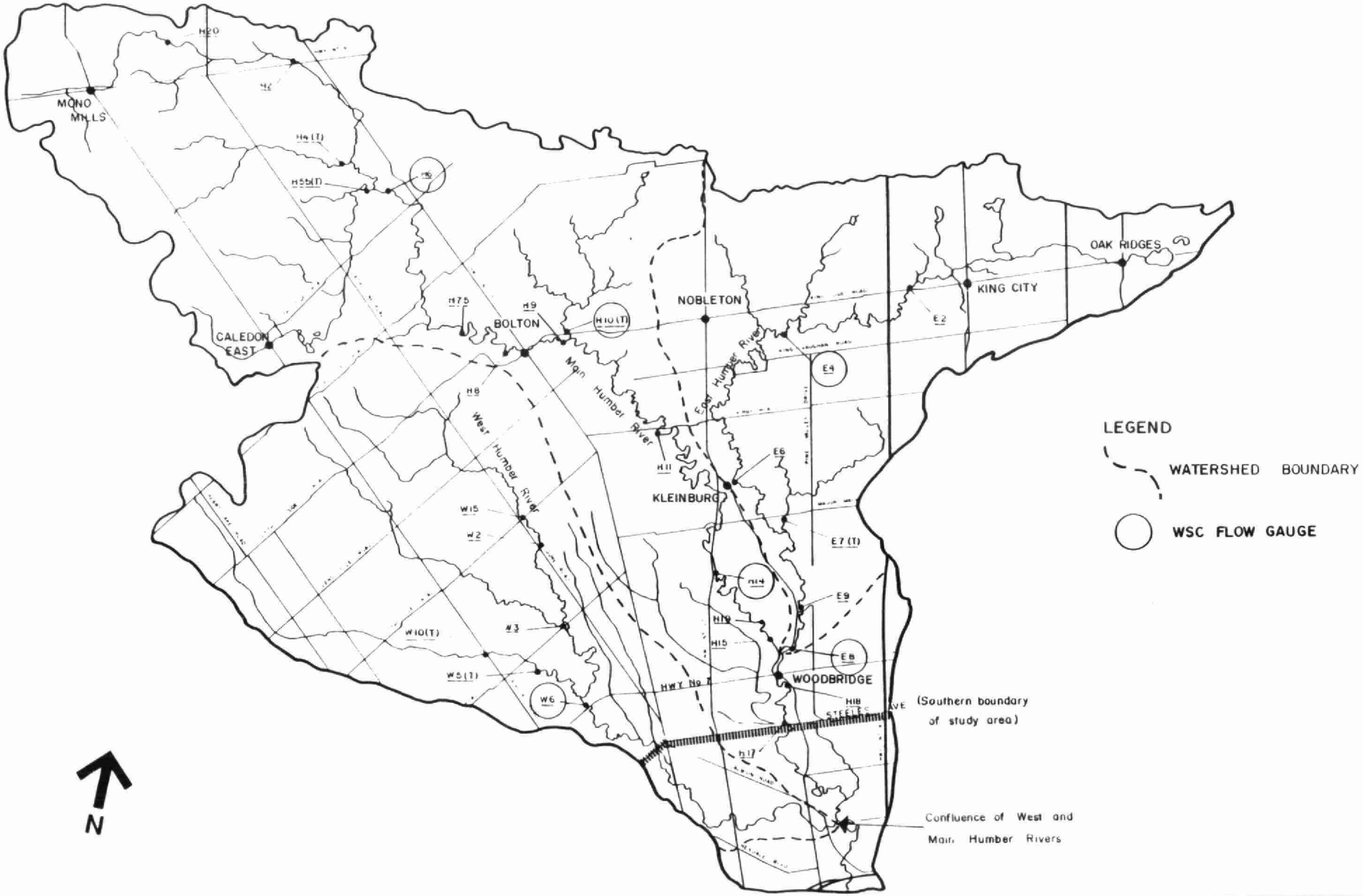
Dry Event Sampling

Event sampling stations were selected based on the results of the synoptic survey. Although several new stations were created, the total number of sampling stations was reduced to 21 for microbiological sampling and 19 for chemical samples (Figure 2.2, Table 2.1).

Table 2.1 **Summary of Study Sampling Stations.**
(An "X" indicates that samples were taken).

STATION*	SYNOPTIC SURVEY		DRY EVENTS		WET EVENT	
	Chemical	Microbiological	Chemical	Microbiological	Chemical	Microbiological
H-1	X	X				
H-20				X		
H-2	X	X		X		
H-3	X	X				
H-4(T)	X	X	X		X	
H-5(T)	X	X				
H-55(T)			X	X	X	X
H-6	X	X	X	X	X	X
H-7	X					
H-75			X		X	X
H-8		X		X		
H-9	X	X	X	X	X	X
H-10(T)	X	X	X	X	X	X
H-11	X		X	X	X	X
H-12		X				
H-13		X				
H-14	X		X		X	
H-19				X		
H-15	X	X	X		X	X
H-18				X		X
H-16(T)	X	X				
H-17	X	X	X	X	X	X
E-1	X	X				
E-2	X	X	X	X		X
E-3(T)	X	X				
E-4	X	X	X	X	X	X
E-5(T)	X	X				
E-6	X	X	X	X	X	X
E-7(T)	X	X	X		X	X
E-9				X		X
E-8	X	X	X	X	X	X
W-1	X	X				
W-15			X		X	
W-2	X	X		X		X
W-3	X	X		X		X
W-4(T)	X	X				
W-10(T)			X	X	X	X
W-5(T)	X	X	X	X	X	X
W-6	X	X	X	X	X	X
W-7(T)	X	X				
W-8(T)	X	X				

* Stations are ordered from source to mouth within each branch.
H - Main Humber River station
E - East Humber River station
W - West Humber River station
(T) - tributary station



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UPPER HUMBER RIVER STUDY

EVENT SAMPLING STATIONS

FIGURE: 2.2

MARCH 1985

2 1 0 1 2 3 Km

Three dry events were sampled between July 23 and December 13, 1984: Dry Event 1 from July 23 to 27, Dry Event 2 from August 27 to September 5, and Dry Event 3 from December 10 to 13. Dry event sampling consisted of taking chemical samples daily for three consecutive days (four days for Dry Event 2), and microbiological samples daily for five consecutive days (four days for Dry Event 3). At least two rain-free days were necessary prior to initiation of dry event sampling. Once sampling for a dry event had begun, however, precipitation could potentially interfere with the dry conditions. Dry Event 1 was completely free from rain. During Dry Event 2 it rained heavily prior to sampling on the third day. Therefore, sample days four and five were postponed until the following week after another two rain-free days had passed. An extra day of chemical sampling was added at this time. Rain also occurred just prior to the fourth day of sampling in Dry Event 3. These rain disturbances were taken into account in interpreting the dry weather data as outlined subsequently.

Stream Flow Monitoring

Six of the chemical sampling stations corresponded to the locations of Water Survey of Canada (WSC) stream flow gauges (Figure 2.2). For the remaining 13 chemistry stations staff gauges were installed and stage-discharge curves established. This allowed the collection of discharge data concurrent with water sampling so that estimates of instantaneous chemical loadings could be calculated. Flow measurements were taken according to the method described by Onn (1980) using either an OTT Model C-31 or a Gurley pygmy-type (Catalogue Number 625) flow meter, the choice of meters being dependent on water depth at the station. No discharge data were obtained for those stations where only microbiological samples were collected.

Wet Event Sampling

Wet event sampling was undertaken from November 11 to 14,1984.

Three intense, short-duration rainfalls on November 9 and 10 preceded a major rain storm which occurred from late November 10 to November 11. For most stations, water samples were collected at 90-minute intervals throughout the initial runoff event. Automatic water samplers (ISCO Model 2100) were employed for chemical sampling at stations H-6, H-10(T), H-14 and E-8, all of which correspond to WSC gauging stations. Chemical samples were taken hourly at these locations.

The large distances between sampling stations necessitated eliminating microbiological stations H-20 and H-2 from wet event sampling and taking microbiological samples at stations H-75 and H-15 rather than at stations H-8 and H-19 respectively. Chemical samples were not taken at station E-2 because no reliable stage-discharge information was available for use in loading calculations. Microbiological sampling was added at station E-7(T). These adjustments to sampling are summarized in Table 2.1.

At each gauged station, river stage was recorded on every sampling occasion and a hydrograph was plotted. This hydrographic information was used to select samples for analysis because, due to budgetary constraints, not all samples collected could be analysed. For the tributary stations, H-4(T), H-55(T), H-10(T) and E-7(T), chemical samples taken throughout the initial runoff period were composited flow-proportionately (Baun 1982).

Subsequent to the intensive sampling, additional samples were taken over the next three days as the rivers gradually returned to near base-flow conditions.

Sample Analysis

Water samples were analysed for the parameters listed in Table 2.2 using standard MOE methods (MOE 1981). Parameter

Table 2.2 **Water Quality Parameters Tested**
(parameter abbreviations are shown in brackets).

Conventional Water Quality Parameters

Total suspended solids/Residue particulate (TSS)
Total dissolved solids/Residue filtrate (TDS)
Conductivity (COND)
Biochemical oxygen demand (BOD)
Total phosphorus (TP)
Orthophosphate/Filtered reactive phosphorus (OP)
* Total Kjeldahl nitrogen (TKN)
* Ammonia nitrogen (AMM-N)
* Nitrate (NO_3^-)
* Nitrite (NO_2^-)

Trace Metals

Copper (Cu)
Lead (Pb)
Cadmium (Cd)
* Zinc (Zn)

Microbiological Parameters

Fecal coliforms M-TEC (FC)
Escherichia coli M-TEC (EC)
Fecal streptococcus M-enterococcus (FS M-ENT)
** Fecal streptococcus M-E (FS M-E)
** Fecal streptococcus K-F (FS K-F)
Pseudomonas aeruginosa (PA)

---

* analysed for Synoptic Survey only.
** analysed for Event samples only.

selection was partially based on the results of a previous TAWMS study (TAWMS 1984) which reported exceedances of water quality objectives/guidelines for fecal coliforms, total phosphorus, total suspended solids, copper, lead and cadmium in the Upper Humber watershed. Microbiological parameters were chosen with a view to relating the relative concentrations of the parameters to identified sources of fecal pollution. As the reliability of the traditional FC:FS ratio (Geldreich and Kenner 1969) for ascertaining pollution sources is questionable, alternative methods of source identification are currently being investigated (M. Young, personal communication). Microbiological data and associated land use information collected during the Upper Humber River Study will contribute to these investigations. Sample analysis for Dry Event 3 was carried out by the Laboratory Services and Applied Research Branch of the MOE. All other samples were analysed at a private laboratory by staff familiar with MOE analytical methods. We feel that some discrepancies in results obtained by the two laboratories may have occurred, particularly in the case of trace metals.

2.3 Bed Sediment Sampling

Bed sediment analysis can provide a more historical perspective on contaminant inputs to a watercourse. To this end, 19 bed sediment samples were collected from November 20 to December 3, 1984. All sampling sites corresponded to water chemistry sampling locations. At each site, samples were collected at river bends or where decreases in water velocity had permitted deposition of fine textured sediments. Sediments were generally collected from three spots across the stream and composited.

All sampling locations were shallow enough to approach wearing hip or chest waders. The samples were scraped from the top 1 to 5 cm of sediment using a plastic scoop affixed to a wooden handle to avoid metal contamination. Each sample was emptied into a large freezer bag and frozen for later analysis. Samples were analysed for total phosphate, copper, lead, zinc and cadmium. To ascertain the degree of physical similarity between samples taken at different stations, samples were fractionated and the percentage composition of each particle size fraction was determined. Clay and silt sized particles (<0.06 mm, King 1972) are generally of most importance because of their mobility and ease of transportation over considerable distances and their strong binding properties with many chemical parameters.

2.4 Overland Sediment Delivery

Sediment loading from rural overland sources was mapped using a methodology developed by the Lands Directorate at the Canada Centre for Inland Waters (CCIW) (Snell 1984). This methodology, an adaptation of the Universal Soil Loss Equation, utilizes a series of map overlays to target areas contributing significant overland sediment volumes to watercourses. While this technique does not quantify sediment inputs, it does allow for the setting of priority management areas.

The output from this mapping technique includes three maps:

1. Field Soil Loss - specifically, Potential Average Annual Soil Loss from Rural Areas, a map classifying areas for their potential to suffer from sheet and rill erosion.

2. Field to Stream Delivery Ratio - specifically, Terrain Capability to Transport Sediment to a Stream, a map classifying areas for their ability to transport available eroded soil to a watercourse.

3. Stream Sediment Load - specifically, Priority

Management Areas for Diffuse Source Sediment Pollution, a map classifying areas with respect to the volume of sediment that is likely to reach a watercourse.

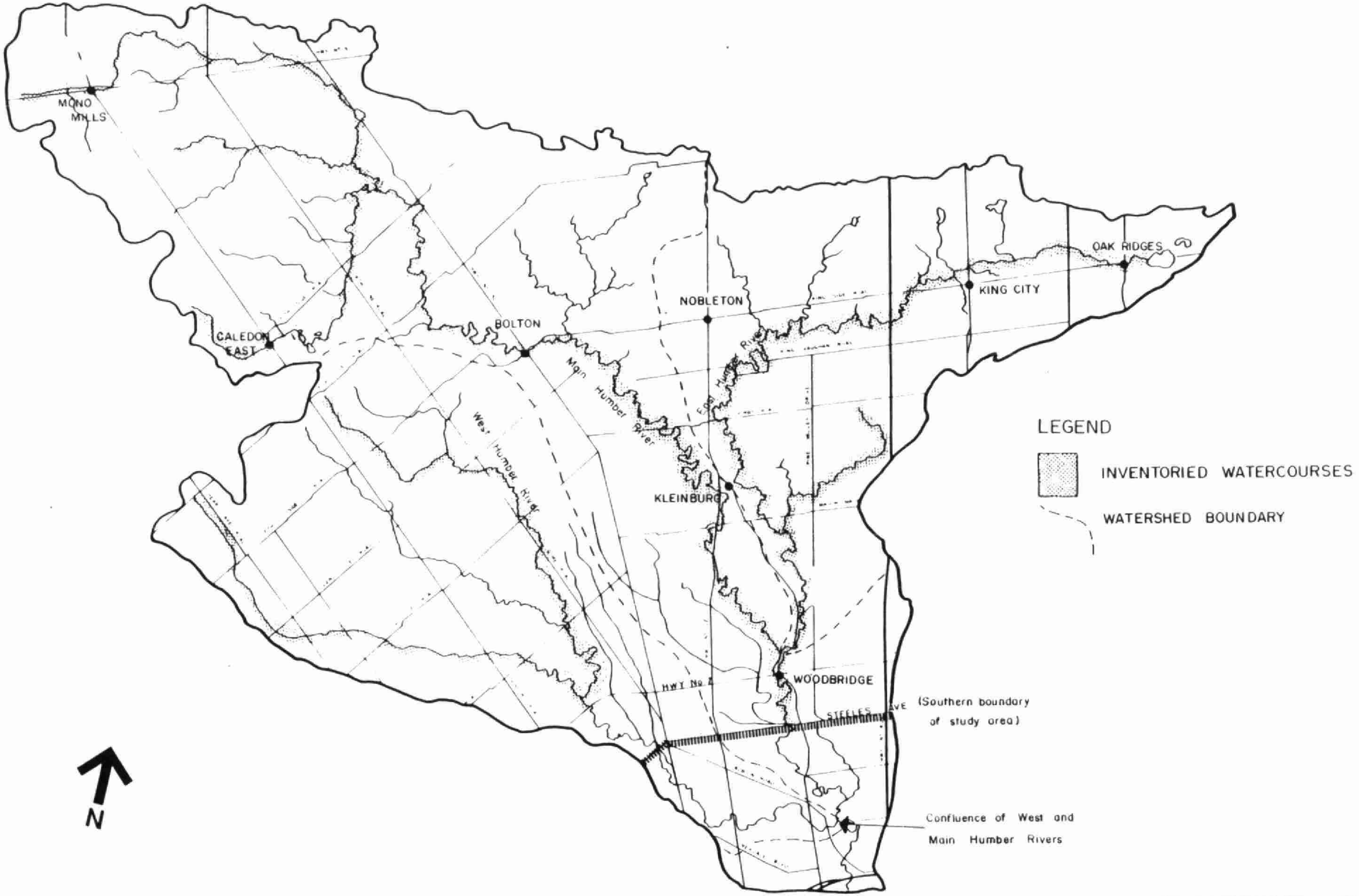
This method of targeting overland sediment inputs has been used extensively during the past several years by the Grand River, Lower Thames and Upper Thames Valley Conservation Authorities. The mapping formed an important component of the Stratford-Avon River Environmental Management Project (SAREMP) conducted between 1980 and 1982 (Coleman 1982). More recently this information was utilized by the Task Force organized to implement the Canada-Ontario Agreement regarding phosphorus reduction to the Great Lakes (G. Wall, personal communication).

2.5 Field Inventory

A field inventory was conducted from June to October, 1984 in an effort to locate potential pollution sources. Two-person crews walked watercourses of the Upper Humber system (Figure 2.3), noting problem land uses (e.g. areas where livestock had free access to the watercourse), point source inflows, and stream bank erosion sites. These features were described using standardized forms and their locations were indicated on topographic maps (1:25,000 or 1:50,000 scale). An example of the forms used in the field, definitions of standard features, and a full description of field methods are presented in Appendix 1.

2.6 Data Analysis and Presentation

Dry Events 2 and 3 were interrupted by rain disturbances. To compensate for this, Dry Event 2 was analysed as two distinct portions: the normal dry portion consisting of



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UPPER HUMBER RIVER STUDY

IDENTIFICATION OF INVENTORIED WATERCOURSES

FIGURE: 2.3

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2 1 0 1 2 3 km

sample days 1, 2 and 5, and the wet portion consisting of sample days 3 and 4. With the exception of day 5 which involved only microbiological sampling, both chemical and microbiological data were available for each sampling day. For Dry Event 3, only the rain-free portion was analysed; sample day 4, the one wet day, was eliminated. Complete water quality data are presented in Appendix 2.

Comparisons to Water Quality Objectives

Water quality data collected during event sampling were compared to Provincial Water Quality Objectives (MOE 1984). If no MOE objectives or guidelines were available, a guideline cited by McNeely *et al*. (1979) was used, if available. At each sampling station, for each event, exceedances were considered in two ways: first, the frequency with which observed concentrations exceeded objectives or guidelines was tabulated, and, second, the degree to which observed concentrations exceeded objectives or guidelines was calculated. The degree of exceedance is presented as a "mean exceedance ratio". For chemical parameters, this was calculated as the arithmetic mean ratio of observed concentrations to the given objective or guideline. For fecal coliform bacteria the water quality objective is based on a geometric mean of samples collected. Therefore, the mean exceedance ratio for fecal coliforms was calculated as the ratio of the observed geometric mean fecal coliform count to the objective. Note that although mean ratios could be less than one, only mean ratios greater than or equal to one are presented in the tables.

Parameter Correlations

For each sampling station, Spearman rank correlation coefficients were calculated using, firstly, all the dry weather chemical data combined and, secondly, the Wet Event chemical data. The variables used in the analysis were the concentrations of all the chemical parameters and corresponding instantaneous discharge values.

Spearman rank correlation coefficients were also determined for the bed sediment data. The variables used were the chemical concentrations and the percentage composition of each grain size category.

All correlation analyses were performed using SYSTAT (1984).

Definition of Subbasins

To better determine the relative importance of chemical and microbiological inputs to the watercourse, a large portion of the data was analysed by the use of subbasins. Subbasin boundaries were defined by the drainage area upstream from each sampling station. It was initially intended that both chemical and microbiological samples would be collected from each site. However, following the Synoptic Survey it was decided that a shift of some of the microbiological sampling stations would be desirable to more closely bracket suspected problem areas such as urban centers. Therefore, since not all parameters were sampled at each station, the relevant subbasin area depends on whether all sampling stations are considered (chemical, chemical/microbiological and microbiological) or only those stations where chemistry samples were taken (i.e. chemical and chemical/microbiological stations). The subbasin drainage areas have been calculated for both situations and are expressed in Table 2.3.

Study results were interpreted by the use of subbasin schematic diagrams. The diagrams accurately depict the relative lengths of the West Humber, East Humber and Humber Rivers as well as the distances between the sampling stations. No tributary lengths were shown when samples were collected at their confluence with the main branches (e.g. H-4(T), H-10(T)). The only exception occurred on the West Humber

Table 2.3 **Subbasin Drainage Areas**
(Indicated are the drainage areas formed between each sampling station. Bracketed areas "( )", indicate drainage areas between chemistry stations only).

Subbasin No.	From Station	-	To Station	Subbasin Drainage Area (km²)	
H-17	H-17	-	H-18	54.90	(56.20)
H-18	H-18	-	H-15	1.30	
H-15	H-15	-	H-19	1.90	(8.60)
H-19	H-19	-	H-14	6.70	
H-14	H-14	-	H-11	13.40	(13.40)
H-11	H-11	-	H-9	16.90	(16.90)
H-9	H-9	-	H-8	7.30	(11.40)
H-8	H-8	-	H-75	4.10	
H-75	H-75	-	H-6	30.42	(30.42)
H-10(T)	H-10		Tributary	62.60	(62.60)
H-6	H-6	-	H-20	16.98	(79.40)
H-55(T)	H-55		Tributary	43.75	(43.75)
H-4(T)	H-4		Tributary	23.30	(23.30)
H-20	H-20	-	H-2	36.43	
H-2	H-2	-	Source	25.99	
E-8	E-8	-	E-9	5.40	(19.18)
E-9	E-9	-	E-6	13.78	
E-7(T)	E-7		Tributary	34.70	(34.70)
E-6	E-6	-	E-4	45.60	(45.60)
E-4	E-4	-	E-2	30.80	(30.80)
E-2	E-2	-	Source	64.20	(64.20)
W-6	W-6	-	W-3	35.59	(51.58)
W-5(T)	W-5		Tributary	37.45	(37.45)
W-10(T)	W-10		Tributary	21.23	(21.23)
W-3	W-3	-	W-2	12.89	
W-2	W-2	-	W-15	3.10	
W-15	W-15	-	Source	32.53	(32.53)

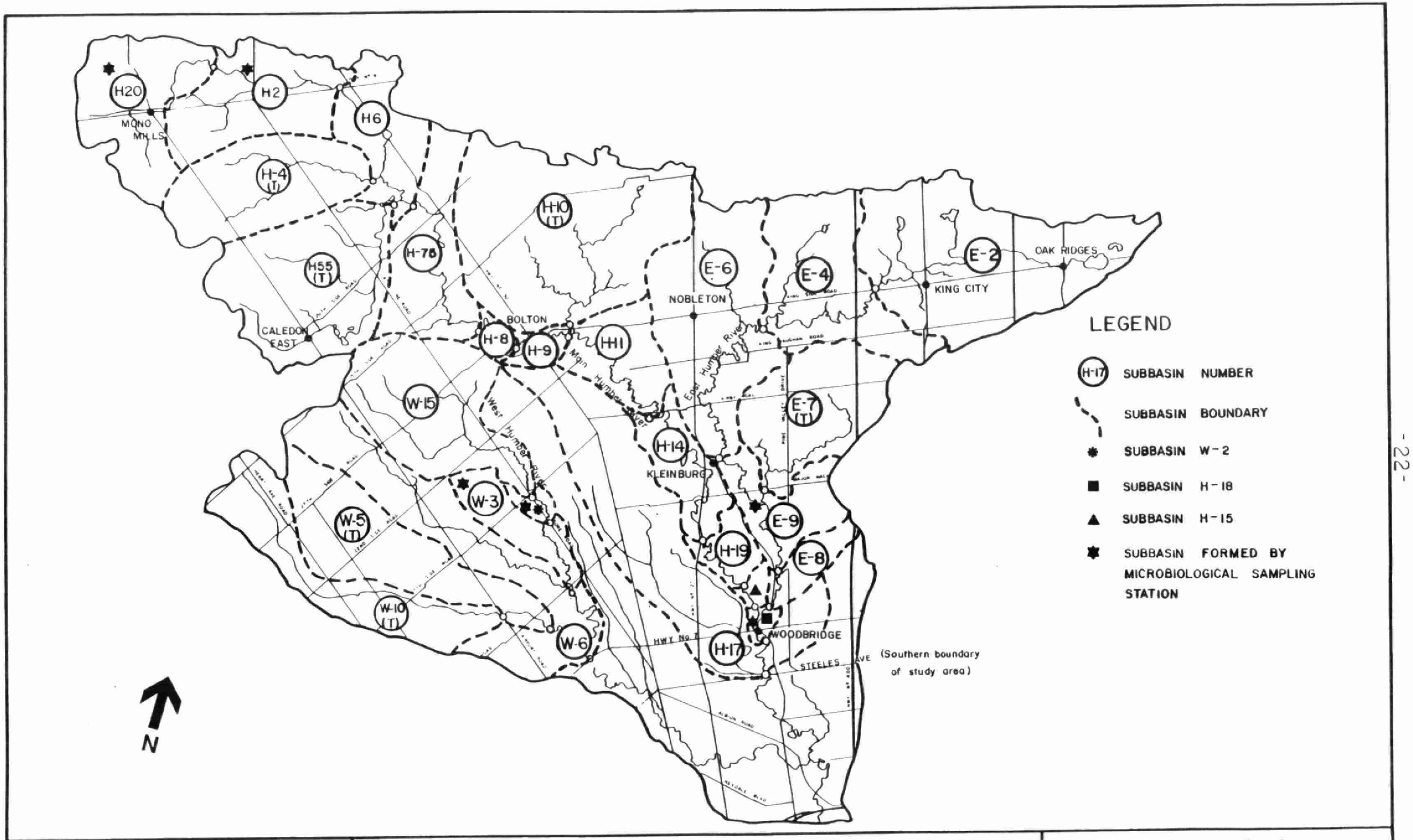
where tributary samples were collected some distance from the confluence (i.e W-5(T), W-10(T)).

Data were depicted on four schematic diagrams entitled "Overland Sediment Delivery by Subbasin", "Percentage Land Use by Subbasin", "Percentage Livestock Access by Subbasin" and "Chemical Loadings by Subbasin". The only exceptions were in the presentation of Point Source Inflow and Streambank Erosion data. These data were also depicted on a subbasin level but bar graphs were utilized as the method of presentation rather than schematic diagrams. All of the above data (except chemical loadings) were analysed on the basis of all sampling stations since these types of information influence both chemical and microbiological concentrations in a watercourse. The schematics depicting subbasin chemical loadings were obviously based only on chemistry stations.

For each of the schematics except Chemical Loadings, the data were presented proportionately on an individual subbasin level. For example, the degree of urban land use within subbasin H-9 is depicted as a percentage of the total land use within that subbasin.

The following points should be considered when viewing the schematics:

1) The size of any subbasin should be considered when assessing its overall significance to the watercourse. For example, in the case of the Overland Sediment Delivery schematic, approximately 15% of subbasin H-10(T) exhibits a high potential for overland sediment delivery while about 25% of subbasin H-11, immediately downstream, has a high delivery potential. However, from looking at Table 2.3 and Figure 2.4 it is obvious that H-10(T) is the much larger of the two subbasins. This means that despite the initial impression presented in the schematic, it is subbasin H-10(T) which exhibits the greater amount of overland sediment delivery and



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SUBBASIN BOUNDARIES

FIGURE: 2.4

MARCH 1985

may possibly be the more significant subbasin in that respect.

2) The subbasin boundaries depicted in Figure 2.4 are formed by the drainage areas between each sampling station, however, as previously mentioned, the relevant subbasin area is dependent on whether one is interested in chemical or microbiological parameters. For example, consider the subbasins H-75 and H-8 above Bolton and subbasin H-9 immediately downstream of the town. Sampling stations H-75 and H-8 are chemistry and microbiological stations respectively while station H-9 combines both chemical and microbiological sampling. In evaluating the change in chemical levels (TSS for example), through the town of Bolton the pertinent area of subbasin H-9 is the entire area between sampling stations H-75 and H-9 (i.e. 11.40 km^2). Station H-8 is not considered because only microbiological samples were collected from that site. When microbiological parameters are of interest, however, the H-9 subbasin is reduced by 4.10 km^2 because of the inclusion of station H-8.

Subbasin Chemical Loadings

Chemical loadings by subbasin were calculated for each event. For the dry events, mean loadings for each subbasin were calculated by averaging the daily instantaneous loadings from the water quality sampling station corresponding to that subbasin. Instantaneous chemical loadings (mass per unit time) were calculated as the product of the subbasin discharge at the time of sampling and the chemical concentration. Wet event chemical loads were defined as the total chemical mass that flowed out of a subbasin during the sampled portion of the event. These loads were calculated from graphs of Wet Event instantaneous chemical loadings versus time using the trapezoidal rule for integration (Riddle 1974). For stations where chemical samples were composited, chemical loads were calculated as the product of the chemical concentration of the composite and the total volume of water discharged during the composite period. For both dry and wet events the chemical contributions (i.e. discharge (Q), TSS, TP, Cu, Cd) of each subbasin are displayed on schematic diagrams of the Upper Humber watershed.

Land Use

The proportion of various land uses was determined for each subbasin using an updated 1:50,000 scale Land Use map compiled by the MTRCA in 1983 (MTRCA 1983). Land use mapping was originally completed in 1979 from a 1:50,000 scale aerial photo mosaic using 1978 photographs (MTRCA 1980).

Five land use categories were differentiated:

Agricultural - Intensively farmed, usually consisting of one or more of the following systems: monoculture, corn, mixed grain or hay.

Pasture - Associated with extensive or unconfined livestock grazing. There should be minimal evidence of recent cultivation.

Open Space - Generally refers to areas that are presently open and where no development is likely to occur (i.e. flood plains, cemeteries etc.).

Forested - Includes natural and plantation forests.

Urban - Includes commercial and industrial development as well as urban and rural residential areas.

As indicated in a previous section, these data are presented in a subbasin schematic diagram.

Overland Sediment Delivery

Only the areas exhibiting High overland sediment delivery were relevant to this study. These areas are depicted on a 1:50,000 scale map included in the map pocket. The proportion of each subbasin composed of these areas was determined. These percentages are presented on a schematic diagram based on both chemical and microbiological sampling stations.

Field Inventory

To facilitate comparison with water quality data, field survey data were summarized on the basis of the subbasins defined by water quality sampling stations, both chemical and microbiological. Summary figures were prepared to highlight stream bank erosion, livestock access, and point source inflows.

3. RESULTS

3.1 Synoptic Survey

Microbiological analyses for fecal coliforms indicated fairly widespread exceedances of the Provincial Water Quality Objective of 100 counts/100 mls (Appendix 2). Geometric mean densities ranged from 40 to 2,113, occurring at stations W-8 and E-8 respectively. The geometric means exceeded the objective at 19 of 30 stations. On the West Humber and Humber Rivers, exceedances occurred at 38% and 64% of the sampling stations respectively. All but one (88%) of the stations on the East Humber exceeded the objective. Escherichia coli densities closely paralleled those of fecal coliform bacteria.

The Provincial Water Quality Objectives (MOE 1984) state that when pathogenic organisms such as Pseudomonas aeruginosa can be enumerated and frequently isolated from water, a potential health hazard exists. Geometric mean densities of P. aeruginosa ranged from <2 which occurred at several stations to 12 on the West Humber at Highway 7 (W-6) and 10 on the Humber River at Steeles Avenue (H-17). The greatest densities generally occurred on the Humber River south of the community of Kleinburg.

Based on these results, some sampling stations were eliminated and others shifted to more adequately sample problem areas. For example, the two stations immediately upstream and downstream of Kleinburg on the Humber River (H-12 and H-13 respectively) were eliminated because the microbiological concentrations actually declined through the community.

Concentrations of the nitrogen parameters (ammonia, total kjeldahl, nitrate (NO_3^-) and nitrite (NO_2^-)) were never in exceedance of suggested water quality guidelines. Similarly, zinc levels were well within the MOE objective of 0.05 mg/l at all stations. Based on these results, samples were not analysed for the above parameters during the remainder of the study.

Total suspended solids exceeded the guideline of 25 mg/l (McNeely *et al*. 1979) at 12 of 30 stations. On the East Humber, the highest level (48 mg/l) was found at station E-8 near Woodbridge. On the West Humber the greatest concentration (98 mg/l) was found at station W-5(T) located on a tributary in the southern portion of the watershed. The highest overall TSS concentration of 124 mg/l was found at station H-14 on the Humber River. All five exceedances occurring on the Humber River were in the southern stretches of the watercourse.

Total phosphorus concentrations exceeded the guideline of 0.03 mg/l at 27 of 30 stations. Values ranged from 0.024 mg/l at E-8 and H-10(T) to 0.132 mg/l at H-14. The highest concentrations were found on the southern stretches of the Humber River above the town of Woodbridge.

Trace metal analyses for Cu, Pb and Cd revealed that widespread exceedances occurred only with Cu. Violations of the MOE objective occurred at 25 of 30 stations. Concentrations ranged from 0.003 mg/l at station H-4(T) to 0.021 mg/l at W-7(T). Although elevated Cu levels were found at W-7(T), the station was eliminated because of extremely low base flows and the strong likelihood that the tributary would become dry during summer periods. Analyses for Pb were maintained through the study because Pb concentrations were uniformly close to exceeding the objective throughout the watershed. In the case of Cd, the laboratory detection limit was above the MOE objective of 0.0002 mg/l (MOE 1984) and it was felt that samples should continue to be analysed for this parameter using more sensitive detection limits.

A complete summary of the Synoptic Survey data is presented in Appendix 2.

3.2 Event Sampling: Comparisons to Water Quality Objectives

Exceedances of water quality objectives or guidelines are presented in Tables 3.1 to 3.10.

Fecal Coliforms (100 counts/100 ml; MOE 1984)

The objective for FC is for the protection of public health (MOE 1984).

Seventy-five percent and 87% of the FC values exceeded the objective for Dry Events 1 and 2 respectively. In contrast, during Dry Event 3 only 28% of the FC values exceeded the objective. For both the Wet Event and the wet portion of Dry Event 2, 98% of the FC values exceeded the objective.

In general, wet weather mean exceedance ratios were greater than dry weather mean exceedance ratios. Wet Event mean exceedance ratios were greater on the West Humber and East Humber Rivers than on the Humber River.

Fecal coliform levels immediately downstream of the towns of Woodbridge and Bolton (i.e. stations H-18, E-8 and H-9) were consistently higher than the FC levels of stations located just upstream from these communities.

Extremely high FC counts regularly occurred at stations H-2 and W-2.

Total Suspended Solids (25 mg/l; McNeely *et al*. 1979)

The MOE does not have an objective or guideline for TSS; the guideline for TSS is for the protection of freshwater life and is cited by McNeely *et al*.(1979).

The TSS guideline was exceeded by 24%, 16% and 5% of the samples for Dry Events 1, 2 and 3 respectively. Exceedances

TABLE 3.1 EXCEEDANCES OF OBJECTIVES/GUIDELINES - DRY EVENT 1

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)	>	>	na	>	na	>	■	■	≤	na	>		na	■	■	■	≤	na	≤	■	>	≤	>	■	■	■	na
TSS (25 mg/l)	>	na	■	na	≤	>		>	na					na	na		na	>				>			na	na	
Total Phosphorus (0.03 mg/l)	■	na	■	na	■	■	■	■	na	>	■	■	>	na	na	■	na	■	■	■	■	■	■	■	na	na	
BOD (10 mg/l)		na		na					na					na	na		na								na	na	
Copper (0.005 mg/l)	■	na	■	na	■	■	■	■	na	■	■	■	■	na	na	■	na	■	■	■	>	■	■	■	na	na	■
Lead (0.025 mg/l)		na		na					na					na	na		na				≤				na	na	
Cadmium (0.0002 mg/l)	no data available																										

LEGEND:

■ - all samples exceeded objective or guideline.

> - >50% of samples exceeded objective or guideline.

≤ - <=50% of samples exceeded objective or guideline.

☐ - no sample exceeded the objective or guideline.

na - not applicable, no sample collected.

TABLE 3.2 MEAN EXCEEDANCE RATIOS - DRY EVENT 1

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)*	1.3	1.9	na	1.8	na	2.3	1.8	3.2		na	1.3		na	13.2	2.6	3.6	1.1	na		3.1	1.9		1.3	3.2	4.5	38.9	na
TSS (25 mg/l)**	1.0	na	1.6	na		1.1			na					na	na		na	1.3				1.1			na	na	
Total Phosphorus (0.03 mg/l)*	2.0	na	2.2	na	1.9	1.8	2.0	2.2	na	1.4	1.7	1.7	1.3	na	na	1.6	na	2.0	2.3	2.1	2.9	2.2	2.4	2.2	na	na	
BOD (10 mg/l)**		na		na					na					na	na		na								na	na	
Copper (0.005 mg/l)*	2.1	na	2.4	na	3.7	2.3	2.5	2.9	na	3.5	4.9	2.7	2.7	na	na	3.3	na	2.3	1.2	1.8	2.4	4.0	2.9	2.9	na	na	3.7
Lead (0.025 mg/l)*		na		na					na					na	na		na								na	na	
Cadmium (0.0002 mg/l)*	- no data available -																										

* Objective for the protection of aquatic life (MOE 1984), with the following exceptions:
(1) there is no firm objective for total phosphorus; the value given for total phosphorus is a general guideline.
(2) the objective for fecal coliforms is for the protection of public health.

** The suspended solids value is a guideline for the protection of freshwater life;
the BOD value is an indicator of organic pollution, not a water quality objective (McNeely et al. 1979).

na - not applicable, no sample collected.

TABLE 3.3 EXCEEDANCES OF OBJECTIVES/GUIDELINES - DRY EVENT 2

PARAMETER / station:	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)	■	■	na	>	na	■	≤	■	■	na	■	>	na	■	■	■	>	na	>	■	■	■	■	■	>	■	na
TSS (25 mg/l)	■	na	■	na	■				na					na	na		na								na	na	
Total Phosphorus (0.03 mg/l)	■	na	■	na	≤	■		≤	na	≤		≤	≤	na	na	≤	na		≤	≤		■		≤	na	na	≤
BOD (10 mg/l)	≤	na		na					na					na	na		na								na	na	
Copper (0.005 mg/l)	■	na	■	na	■	■	■	■	na	≤	■	■	≤	na	na	≤	na	≤	≤	■	■	≤	■	■	na	na	≤
Lead (0.025 mg/l)	≤	na		na	≤	≤	≤	≤	na	≤	≤	■	■	na	na	■	na	■	■	■	■	■	■	■	na	na	≤
Cadmium (0.0002 mg/l)		na	≤	na	≤	■	≤		na		≤	■	■	na	na	≤	na	■	■	≤	■	≤	■	■	na	na	■

LEGEND:

■ - all samples exceeded objective or guideline.

> - >50% of samples exceeded objective or guideline.

≤ - <=50% of samples exceeded objective or guideline.

☐ - no sample exceeded the objective or guideline.

na - not applicable, no sample collected.

TABLE 3.4 MEAN EXCEEDANCE RATIOS - DRY EVENT 2

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)*	3.8	4.6	na	1.9	na	3.0		2.2	1.9	na	1.7	1.0	na	31.1	1.7	7.5		na	1.3	2.3	2.9	2.9	5.2	4.6	2.3	14.9	na
TSS (25 mg/l)**	1.1	na	1.7	na	1.5				na					na	na		na								na	na	
Total Phosphorus (0.03 mg/l)*	1.8	na	2.8	na	1.9	2.0		1.5	na	1.0		1.2		na	na		na		1.0			1.7			na	na	1.1
BOD (10 mg/l)**		na		na					na					na	na		na								na	na	
Copper (0.005 mg/l)*	1.6	na	1.7	na	2.2	1.4	1.6	4.4	na	2.0	2.6	2.7	1.8	na	na	1.2	na	2.0	3.0	2.2	1.2	1.4	2.2	7.4	na	na	1.2
Lead (0.025 mg/l)*		na		na	1.0		1.0	1.0	na		1.2	1.4	1.4	na	na	2.1	na	1.7	1.8	1.5	1.6	1.3	1.5	1.4	na	na	1.2
Cadmium (0.0002 mg/l)*		na	2.5	na	1.2	2.5	2.5		na		2.5	6.2	6.2	na	na	2.5	na	3.8	5.0	2.5	3.8	1.2	6.2	2.5	na	na	38.8

* Objective for the protection of aquatic life (MOE 1984), with the following exceptions:
(1) there is no firm objective for total phosphorus; the value given for total phosphorus is a general guideline.
(2) the objective for fecal coliforms is for the protection of public health.

** The suspended solids value is a guideline for the protection of freshwater life;
the BOD value is an indicator of organic pollution, not a water quality objective (McNeely et al. 1979).

na - not applicable, no sample collected.

TABLE 3.5 EXCEEDANCES OF OBJECTIVES/GUIDELINES - DRY EVENT 3

PARAMETER / station:	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)	≤	■	na	☐	na	>	☐	■	☐	na	☐	☐	na	■	☐	■	☐	na	☐	>	■	☐	☐	≤	☐	☐	na
TSS (25 mg/l)	☐	na	≤	na	>	☐	☐	☐	na	☐	☐	☐	☐	na	na	☐	na	☐	☐	☐	☐	☐	☐	☐	na	na	☐
Total Phosphorus (0.03 mg/l)	☐	na	>	na	■	☐	☐	■	na	≤	☐	☐	☐	na	na	☐	na	☐	☐	☐	>	☐	☐	☐	na	na	☐
BOD (10 mg/l)	☐	na	☐	na	☐	☐	☐	☐	na	☐	☐	☐	☐	na	na	☐	na	☐	☐	☐	☐	☐	☐	☐	na	na	☐
Copper (0.005 mg/l)	☐	na	☐	na	☐	☐	☐	☐	na	☐	☐	☐	☐	na	na	☐	na	☐	☐	☐	☐	☐	☐	☐	na	na	☐
Lead (0.025 mg/l)	☐	na	☐	na	☐	☐	☐	☐	na	☐	☐	☐	☐	na	na	☐	na	☐	☐	☐	☐	☐	☐	☐	na	na	☐
Cadmium (0.0002 mg/l)	☐	na	☐	na	☐	☐	☐	☐	na	☐	☐	☐	☐	na	na	☐	na	☐	☐	☐	☐	☐	☐	☐	na	na	☐

LEGEND:

■ - all samples exceeded objective or guideline.

> - >50% of samples exceeded objective or guideline.

≤ - <=50% of samples exceeded objective or guideline.

☐ - no sample exceeded the objective or guideline.

na - not applicable, no sample collected.

TABLE 3.6 MEAN EXCEEDANCE RATIOS - DRY EVENT 3

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)*		2.4	na		na	1.5		2.2		na			na	6.5		6.5		na		1.0	4.9						na
TSS (25 mg/l)**		na		na	1.0				na					na	na		na								na	na	
Total Phosphorus (0.03 mg/l)*		na	1.0	na	1.5			1.6	na					na	na		na				1.1				na	na	
BOD (10 mg/l)**		na		na					na					na	na		na								na	na	
Copper (0.005 mg/l)*		na		na					na					na	na		na								na	na	
Lead (0.025 mg/l)*		na		na					na					na	na		na								na	na	
Cadmium (0.0002 mg/l)*		na		na					na					na	na		na								na	na	

* Objective for the protection of aquatic life (MOE 1984), with the following exceptions:
(1) there is no firm objective for total phosphorus; the value given for total phosphorus is a general guideline.
(2) the objective for fecal coliforms is for the protection of public health.

** The suspended solids value is a guideline for the protection of freshwater life;
the BOD value is an indicator of organic pollution, not a water quality objective (McNeely et al.,1979).

na - not applicable, no sample collected.

TABLE 3.7 EXCEEDANCES OF OBJECTIVES/GUIDELINES - DRY EVENT 2 (wet portion)

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)	■	■	na	■	na	■	≤	■	■	na	■	■	na	■	■	■	■	na	■	■	■	■	■	■	■	■	na
TSS (25 mg/l)	■	na	■	na	■	■	≤	■	na	≤	≤	☐	≤	na	na	≤	na	■	■	≤	■	■	≤	≤	na	na	☐
Total Phosphorus (0.03 mg/l)	■	na	☐	na	■	■	■	■	na	■	■	■	■	na	na	■	na	■	■	■	■	■	■	■	na	na	≤
BOD (10 mg/l)	☐	na	☐	na	☐	☐	☐	☐	na	☐	☐	☐	☐	na	na	☐	na	☐	☐	☐	☐	☐	☐	☐	na	na	☐
Copper (0.005 mg/l)	■	na	■	na	■	■	≤	■	na	≤	■	■	■	na	na	≤	na	■	■	■	■	■	■	■	na	na	■
Lead (0.025 mg/l)	■	na	■	na	■	■	■	■	na	■	■	■	■	na	na	■	na	■	■	■	■	■	■	■	na	na	≤
Cadmium (0.0002 mg/l)	≤	na	≤	na	≤	■	■	■	na	■	≤	☐	≤	na	na	≤	na	■	■	■	■	■	■	≤	na	na	■

LEGEND:

■ - all samples exceeded objective or guideline.

> - >50% of samples exceeded objective or guideline.

≤ - <=50% of samples exceeded objective or guideline.

☐ - no sample exceeded the objective or guideline.

na - not applicable, no sample collected.

TABLE 3.8 MEAN EXCEEDANCE RATIOS - DRY EVENT 2 (wet portion)

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10	H9	H8	H75	H6	H55	H4	H2	H20	E8	E9	E7	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)*	53.6	35.8	na	39.1	na	47.0	6.4	23.0	8.7	na	14.2	2.7	na	79.3	9.2	22.3	8.2	na	7.1	23.0	85.4	26.0	40.5	37.7	39.6	26.2	na
TSS (25 mg/l)**	17.4	na	20.4	na	15.9	17.4	1.9	5.7	na	1.2	1.4		3.4	na	na	2.4	na	12.4	3.1	2.2	6.1	5.8	8.3	4.3	na	na	
Total Phosphorus (0.03 mg/l)*	10.8	na	7.0	na	15.0	17.8	2.6	5.1	na	2.2	2.8	2.6	4.4	na	na	2.8	na	3.1	1.7	1.8	2.3	5.3	7.1	5.3	na	na	1.0
BOD (10 mg/l)**		na		na					na					na	na		na								na	na	
Copper (0.005 mg/l)*	5.0	na	4.6	na	4.1	6.1	1.6	2.6	na	2.0	1.8	2.5	2.1	na	na	2.5	na	6.4	2.1	2.8	3.4	3.0	6.4	3.8	na	na	4.0
Lead (0.025 mg/l)*	2.8	na	2.8	na	2.7	3.4	1.6	1.6	na	1.4	1.5	1.3	1.6	na	na	2.0	na	3.3	2.2	2.2	1.9	1.9	2.0	1.5	na	na	1.5
Cadmium (0.0002 mg/l)*	30.0	na	22.5	na	25.0	41.2	10.8	15.0	na	2.5	9.5		13.0	na	na	6.2	na	46.2	6.2	8.8	13.8	20.0	42.5	16.2	na	na	3.8

* Objective for the protection of aquatic life (MOE 1984), with the following exceptions:
(1) there is no firm objective for total phosphorus; the value given for total phosphorus is a general guideline.
(2) the objective for fecal coliforms is for the protection of public health.

** The suspended solids value is a guideline for the protection of freshwater life;
the BOD value is an indicator of organic pollution, not a water quality objective (McNeely et al.,1979).

na - not applicable, no sample collected.

TABLE 3.9 EXCEEDANCES OF OBJECTIVES/GUIDELINES - WET EVENT

PARAMETER / station:	H17	H18	H15	H19	H14	H11	H10 x	H9	H8	H75	H6	H55 x	H4 x	H2	H20	E8	E9	E7 x	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)	■	■	>	na	na	■	■	>	na	>	■	■	na	na	na	■	■	■	■	■	■	■	■	■	■	■	na
TSS (25 mg/l)	■	na	■	na	■	>	≤	■	na	■	>		≤	na	na	>	na	≤	>	>	na	>	>	>	na	na	>
Total Phosphorus (0.03 mg/l)	■	na	■	na	■	■	■	■	na	■	>	≤	≤	na	na	■	na	≤	■	■	na	■	■	■	na	na	■
BOD (10 mg/l)		na		na					na					na	na		na				na				na	na	
Copper (0.005 mg/l)	■	na	■	na	■	>	■	■	na	>	■	≤	≤	na	na	■	na	≤	>	>	na	■	>	>	na	na	>
Lead (0.025 mg/l)	>	na	≤	na	>	>	■	>	na	≤	>			na	na	>	na	≤	>	>	na	>	≤	≤	na	na	>
Cadmium (0.0002 mg/l)	■	na	■	na	■	■	■	■	na	■	■	■	■	na	na	■	na	■	■	>	na	■	■	■	na	na	■

LEGEND:

■ - all samples exceeded objective or guideline.

> - >50% of samples exceeded objective or guideline.

≤ - <=50% of samples exceeded objective or guideline.

☐ - no sample exceeded the objective or guideline.

na - not applicable, no sample collected.

x - Chemical exceedances for H55, H4, E7 are based on one composite sample and one discrete sample; chemical exceedances for H10 are based on two composite samples.

TABLE 3.10 MEAN EXCEEDANCE RATIOS - WET EVENT

station: PARAMETER	H17	H18	H15	H19	H14	H11	H10 ※	H9	H8	H75	H6	H55 ※	H4 ※	H2	H20	E8	E9	E7 ※	E6	E4	E2	W6	W5	W10	W3	W2	W15
Fecal Coliforms (100cts/100ml)*	24.8	13.6	7.4	na	na	14.9	7.9	11.0	na	7.3	5.6	3.1	na	na	na	30.5	14.2	43.9	12.8	31.4	50.8	50.4	44.4	32.1	93.5	67.8	na
TSS (25 mg/l)**	7.0	na	5.4	na	5.5	7.4	1.7	8.1	na	6.1	8.4			na	na	4.8	na	4.9	4.3	3.4	na	6.8	2.5	1.9	na	na	3.0
Total Phosphorus (0.03 mg/l)*	9.3	na	6.0	na	7.4	7.7	2.3	7.8	na	6.5	9.0	1.3	3.0	na	na		na	5.7	4.3	4.8	na	11.0	7.6	5.2	na	na	7.3
BOD (10 mg/l)**		na		na					na					na	na	5.4	na				na				na	na	
Copper (0.005 mg/l)*	2.3	na	2.1	na	3.6	2.3	3.3	2.3	na	1.7	3.0	1.9	2.8	na	na	3.5	na	2.9	2.4	2.2	na	2.6	8.2	1.9	na	na	1.8
Lead (0.025 mg/l)*	1.4	na		na	1.2	1.2	1.1	1.3	na	1.0	1.2			na	na	1.1	na	1.1	1.1	1.1	na	1.2	1.0		na	na	1.1
Cadmium (0.0002 mg/l)*	24.6	na	12.5	na	22.7	14.4	16.2	15.9	na	12.7	17.3	10.0	12.5	na	na	19.2	na	22.5	12.3	12.7	na	25.0	15.8	14.6	na	na	17.5

* Objective for the protection of aquatic life (MOE 1984), with the following exceptions:
(1) there is no firm objective for total phosphorus; the value given for total phosphorus is a general guideline.
(2) the objective for fecal coliforms is for the protection of public health.

** The suspended solids value is a guideline for the protection of freshwater life;
the BOD value is an indicator of organic pollution, not a water quality objective (McNeely et al. 1979).

na - not applicable, no sample collected.

※ - Chemical exceedances for H55, H4, E7 are based on one composite sample and one discrete sample;
chemical exceedances for H10 are based on two composite samples.

occurred only in the lower portion of the watershed, and were limited to seven stations in Dry Event 1 (H-17, H-15, H-14, H-11, H-9, E-7(T), W-6), three stations in Dry Event 2 (H-17, H-15, H-14), and two stations in Dry Event 3 (H-15, H-14). Dry weather mean exceedance ratios were low.

Sixty-eight percent of samples collected during the wet portion of Dry Event 2 exceeded the guideline, as did 84% of samples collected during the Wet Event. With the exception of station H-55(T), wet weather exceedances occurred at all stations. Station H-55(T) was located immediately downstream of the swimming pond in Albion Hills Conservation Area; suspended particles likely settle in the pond before reaching the sampling station. Mean exceedance ratios for the wet portion of Dry Event 2 were generally greater than those recorded for the Wet Event; the greatest exceedances occurred in the lower stretches of the Humber River.

Total Phosphorus (0.03 mg/l; MOE 1984)

There is no firm objective for TP, however, MOE(1984) does suggest a general guideline to eliminate excessive growth of aquatic vegetation in watercourses.

The percentage of samples which exceeded the TP guideline was 91% in Dry Event 1, 47% in Dry Event 2, and 19% in Dry Event 3. Ninety-seven percent and 94% of samples exceeded the guideline for the wet portion of Dry Event 2 and the Wet Event, respectively.

Dry weather mean exceedance ratios were uniformly low throughout the study area. As noted for TSS, TP mean exceedance ratios for the wet portion of Dry Event 2 were highest in the lower stretches of the Humber River and were generally greater than the TP mean exceedance ratios of the Wet Event.

BOD (10 mg/l; McNeely *et al*. 1979)

No MOE objective has been established for BOD, however water with BOD levels greater than 10 mg/l are considered polluted by degradable organic material (McNeely *et al*. 1979).

The only exceedance of the BOD guideline occurred during Dry Event 2 when a value of 10.5 mg/l was recorded at station H-17.

Copper (0.005 mg/l; MOE 1984)

The objective for Cu was established for the protection of aquatic life (MOE 1984).

The Cu objective was exceeded by 98% and 82% of the samples for Dry Events 1 and 2 respectively. In contrast, no exceedances were recorded for Dry Event 3. During wet weather sampling the objective was exceeded by 92% and 88% of the samples for the wet portion of Dry Event 2 and the Wet Event respectively.

For all events except Dry Event 3, mean exceedance ratios were greater than one at all sampling stations. Generally these mean exceedance ratios were similar for both dry and wet weather samples, although some of the mean exceedance ratios during wet conditions were actually lower than those recorded for Dry events 1 and 2. This may indicate that dry weather sources of Cu were diluted in wet conditions.

Lead (0.025 mg/l; MOE 1984)

The objective for Pb was established for the protection of aquatic life (MOE 1984).

The Pb objective was never exceeded during Dry Event 3 and on only one occasion during Dry Event 1. In contrast, exceedances occurred in 71% of the samples during Dry Event 2; all stations except H-15 had at least one exceedance. Lower base flows during Dry Event 2 may have reduced the watershed's capacity to dilute Pb inputs resulting in higher Pb concentrations during this event.

Mean exceedance ratios were uniformly low throughout the watershed.

Cadmium (0.0002 mg/l; MOE 1984)

The MOE's objective for Cd was established for the protection of aquatic life (MOE 1984).

No Cd data were available for Dry Event 1 due to continued difficulty in achieving the necessary detection limit. Sixty-six percent of Dry Event 2's Cd samples exceeded the objective. No Cd exceedances occurred in Dry Event 3. In Dry Event 2 (wet portion), 76% of samples exceeded the objective, and of the Wet Event samples, all but one (99%) exceeded the objective.

The highest dry weather Cd levels for the Humber River were recorded in Dry Event 2 from the tributary stations H-55(T) and H-4(T), both of which had mean exceedance ratios of 6.2. The highest overall dry weather mean exceedance ratio was one of 38.8 at station W-15 for Dry Event 2. In contrast to Cu and Pb which had similar concentrations in dry and wet conditions, Cd concentrations increased dramatically during wet weather. The maximum mean exceedance ratio of 46.2 occurred at station E-7(T) in the wet portion of Dry event 2.

3.3 Parameter Correlations

Results of correlation analysis on the surface water quality

Table 3.11 **Occurrence of Significant Correlations.**
(Shown are the percentages of stations which had the given correlations at $p<0.05$. "+" indicates positive correlations, "-" indicates negative correlations.)

		Q	TSS	TDS	COND	OP	TP	BOD	Cu	Pb
TSS	- dry	-5								
	- wet	+50								
TDS	- dry	+32	-32							
	- wet	-14	-7							
COND	- dry	+53	-42	+47						
	- wet	-14	-7	+7						
OP	- dry	-26	+37	-16	-32					
	- wet	+43	+64	0	0					
TP	- dry	-16	+63	-16	-42	+63				
	- wet	+50	+71	0	0	+71				
BOD	- dry	+5	+5,-5	0	10	+5,-21	+5,-5			
	- wet	+7,-7	+7	-7	0	+7	+14			
Cu	- dry	-21	+32	-16	-42	+53	+42	+5,-10		
	- wet	0	+14	0	-7	+14	+14	+7		
Pb	- dry	-42	+32	-74	-58	+10	+10	+5	+53	
	- wet	+7	+21	0	0	+21	+21	0	+7	
Cd	- dry	0	0	0	0	0	0	0	0	0
	- wet	+14	+21	0	0	+14	+21	+7	+28	+28

data are summarized in Table 3.11.

In dry weather, TDS and COND were positively correlated with Q and negatively correlated with TSS and Pb. Positive correlations occurred frequently between TSS and each of OP, TP, Cu and Pb, between Cu and each of OP, TP, and Pb, and between TP and OP.

Some changes in parameter correlations occurred in the Wet Event. Total suspended solids, OP, and TP became positively correlated with Q; OP, TP, and Cd exhibited more frequent correlations with TSS, whereas Cu and Pb correlations with TSS were less frequent. Copper and Pb were no longer negatively correlated with Q. Cadmium became positively correlated with Cu and Pb.

A complete list of significant correlations by sampling station is given in Appendix 3.

3.4 Description of Wet Event

For the purposes of the study, the Wet Event period encompassed six days, from November 9 to 14, 1984. The event was considered to run from 12:00 AM, Friday November 9 (0 hours) to 12:00 AM, Thursday November 15 (144 hours). To avoid possible confusion when comparing hydrographs or pollutographs from various stations, this six-day period will be hereafter referred to in terms of total event time (0 to 144 hours).

The rainfall intensity (mm/0.5 hour) and the cumulative rainfall depth (mm) are presented in Figure 3.1. The rainfall intensity was recorded by an automatic rain gauge located at the Kortright Centre for Conservation, near Kleinburg. The data were stored for later access by the MTRCA's Flood Warning computer system. A total of 35 mm of

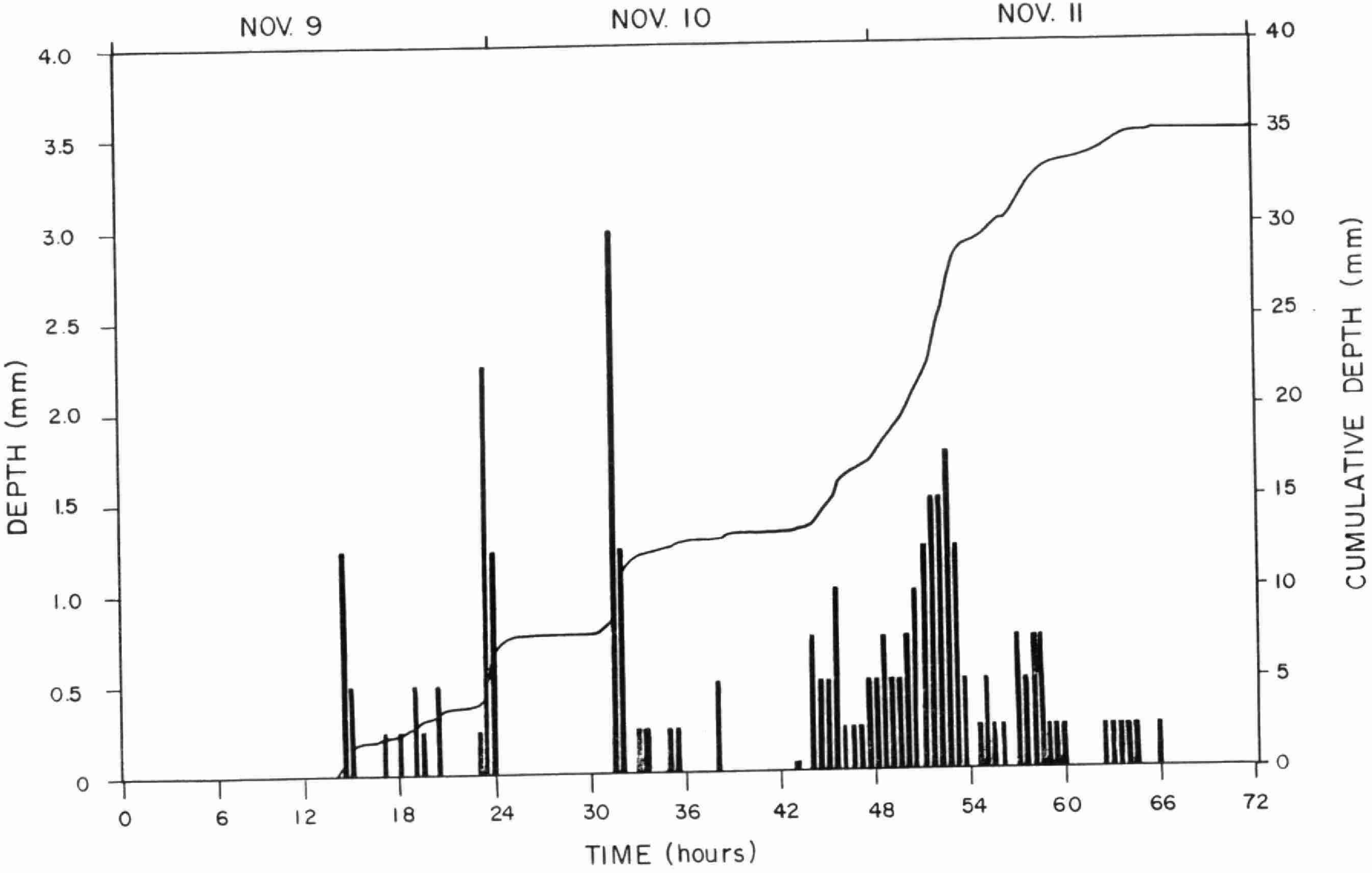

FIGURE 3.1

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UPPER HUMBER RIVER STUDY

WET EVENT PRECIPITATION DATA

FIGURE: 3.1

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rain fell between the afternoon of November 9 and the early evening of November 11. The major portion of the event occurred between 42 and 66 hours (November 10 and 11), when 22 mm of rain fell. These heavy rains were preceded by three intense rainfalls of short duration.

Precipitation data analysis after the event suggested the rainfall was fairly evenly distributed throughout the study area (D. Haley, personal communication). For this reason, the Kortright precipitation data were considered to be representative of the entire study area.

Examples of typical hydrographs are presented in Figures 3.2 to 3.4. These three stations were chosen because they correspond to WSC gauging stations and, therefore, complete hydrographic records were available. Stations E-8 and W-6 correspond to the mouth of the East Humber River and the study "mouth" of the West Humber River respectively. Station H-14 is the first WSC gauging station on the Humber River upstream of its confluence with the East Humber River.

On the figures,the period of rainfall in the study area, the flow event, and the sampled portion of the flow event are shown for each station. The "flow event" was defined as the interval from the first rise in the hydrograph at that station until a return to near base flow when the final chemical samples were taken. The period of sampling indicated refers to chemical and microbiological sampling; not included are additional microbiological samples which were collected on November 14.

It can be seen from Figures 3.2 to 3.4 that, based on discharge, significant percentages of the flow event were sampled at each station. As previously mentioned, Wet Event chemical loads were defined as the total chemical mass that flowed out of a subbasin during the sampled portion of the event. Caution must be exercised in making comparisons of

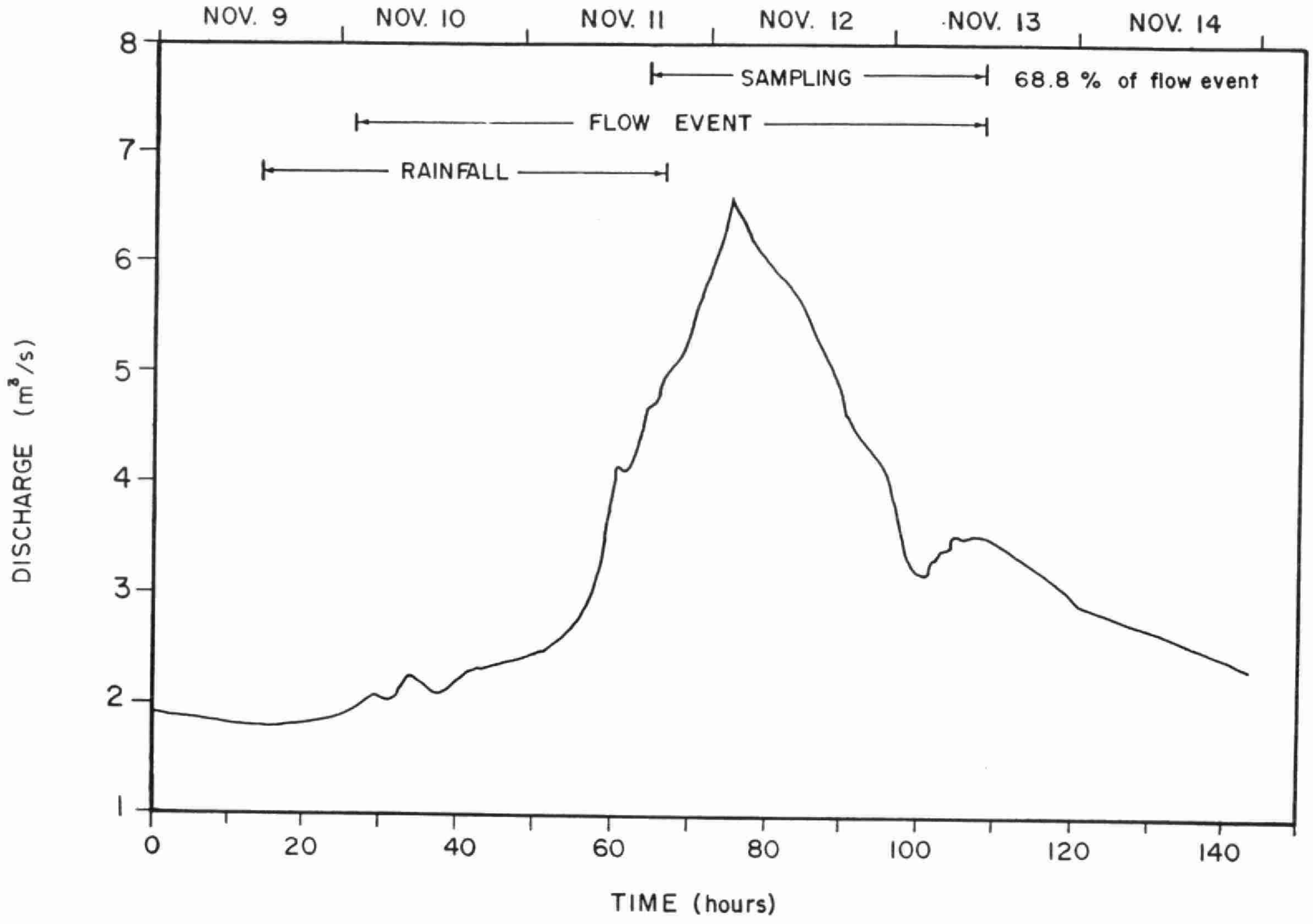

FIGURE 3.2

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SAMPLING STATION H-14
WET EVENT HYDROGRAPH

FIGURE: 3.2

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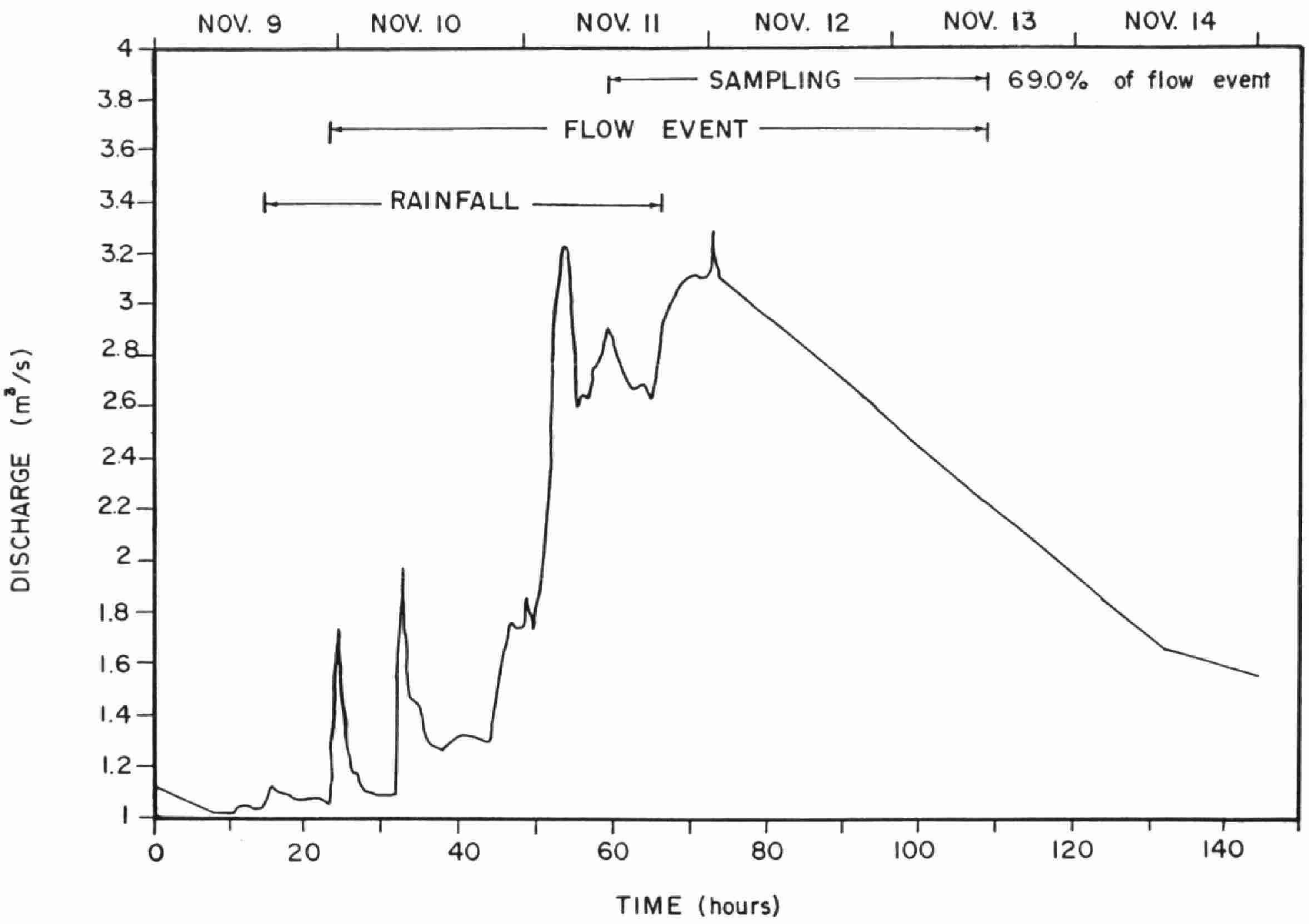

FIGURE 3.3

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FIGURE: 3.3

SAMPLING STATION E-8
WET EVENT HYDROGRAPH

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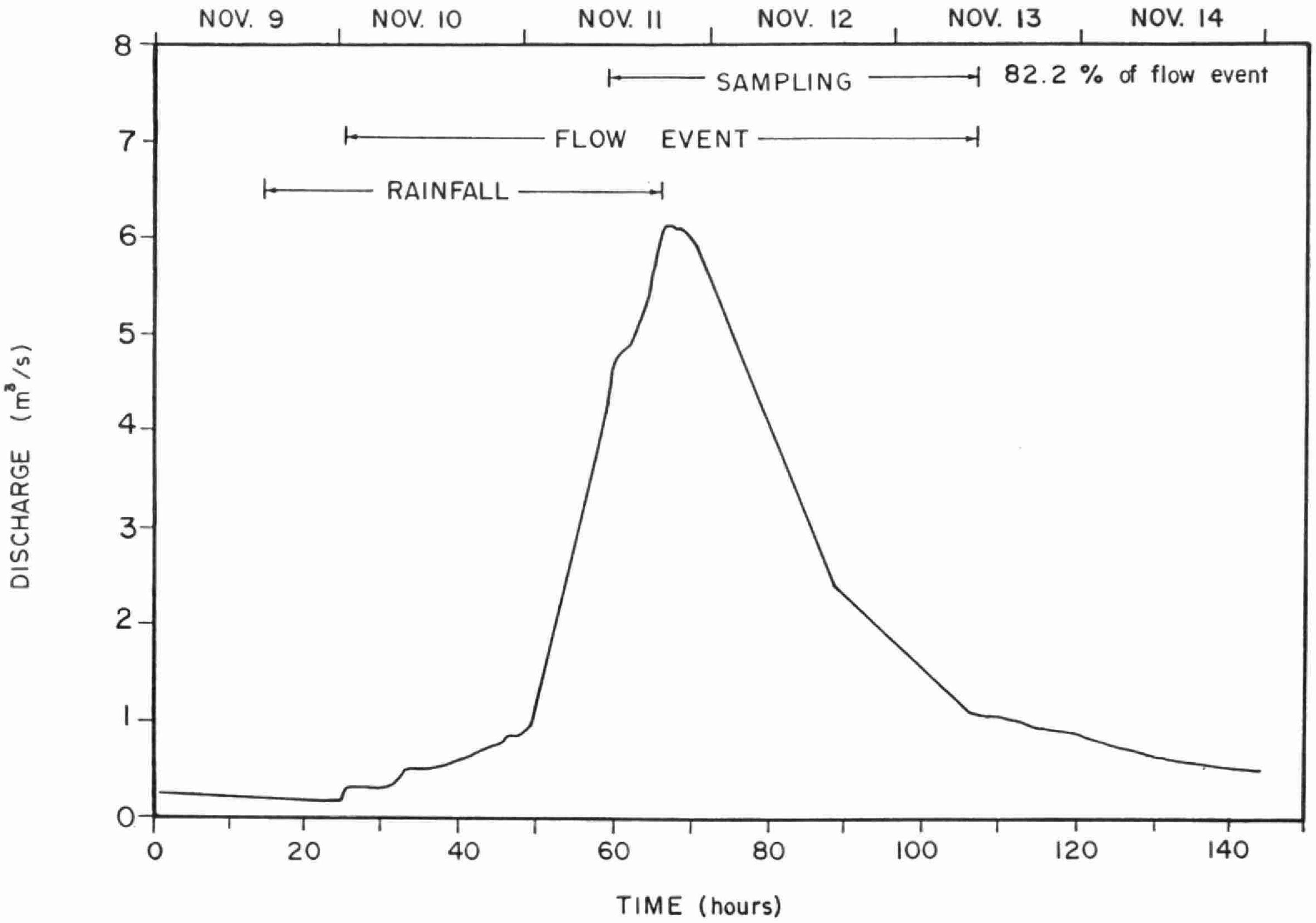

FIGURE 3.4

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FIGURE: 3.4

SAMPLING STATION W-6
WET EVENT HYDROGRAPH

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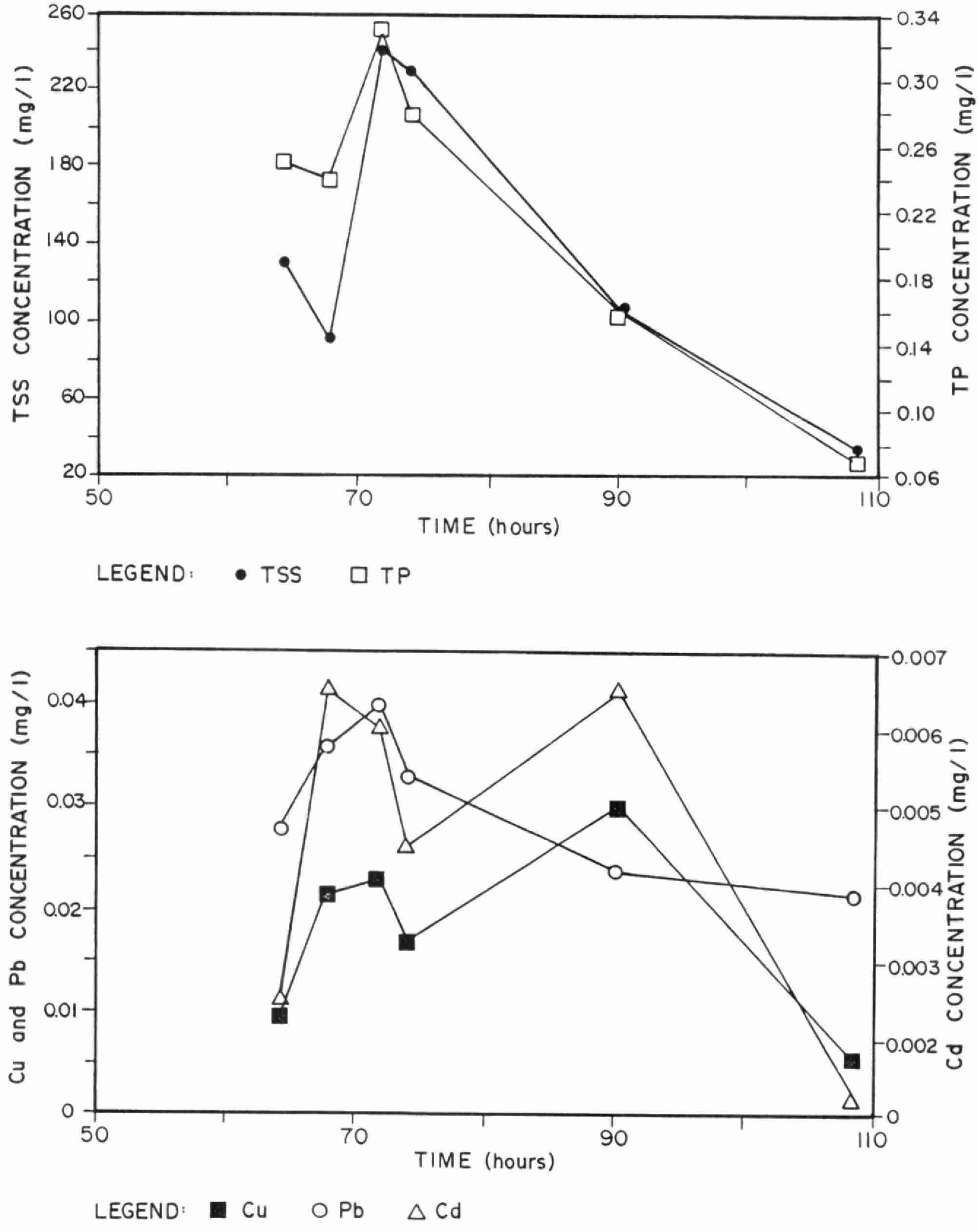
chemical loadings between stations because some spurious differences may occur if the portion of the flow event sampled was not exactly the same at each station. The hydrographs given as examples are more or less typical of all the sampling stations in that the peaks and falling portions of the hydrographs were sampled.

It is obvious from the hydrographs that, compared to subbasins H-14 and W-6, subbasin E-8 exhibited a much more pronounced response to the initial storms. Sharp spikes occurred in the hydrograph at 24 and 33 hours, two periods of intense rainfall. The greater sensitivity of subbasin E-8 to these short-lived storms may reflect the more urban nature of this subbasin. Rapid rises in river levels would result from storm water running quickly off street surfaces to the river via storm sewers. The subsequent major rain storm resulted in two coequal peaks at E-8 separated by approximately 20 hours. The initial and latter peaks may result from initial storm water runoff in subbasin E-8 and upstream contributions respectively. The hydrograph at station W-6 peaked just prior to the second peak at E-8. Peak flows on the Humber River at station H-14 occurred approximately 3 to 5 hours later than the peaks on the East and West Humber Rivers. Note that the West Humber River, which had been intermittent in the summer, had a peak discharge nearly equivalent to that of the Humber River above Woodbridge.

Examples of "pollutographs", plots of chemical concentrations versus time, are given in Figures 3.5 to 3.7. At station E-8 the concentrations of TSS, TP, Cu, Pb and Cd all closely paralleled discharge. At station H-14 parameter concentrations also paralleled discharge, although Cd and Cu concentrations increased again approximately 15 hours after the hydrographic peak. Compared to stations H-14 and E-8, obvious differences occurred in the temporal pattern of contaminant inputs at station W-6. At this station the peak



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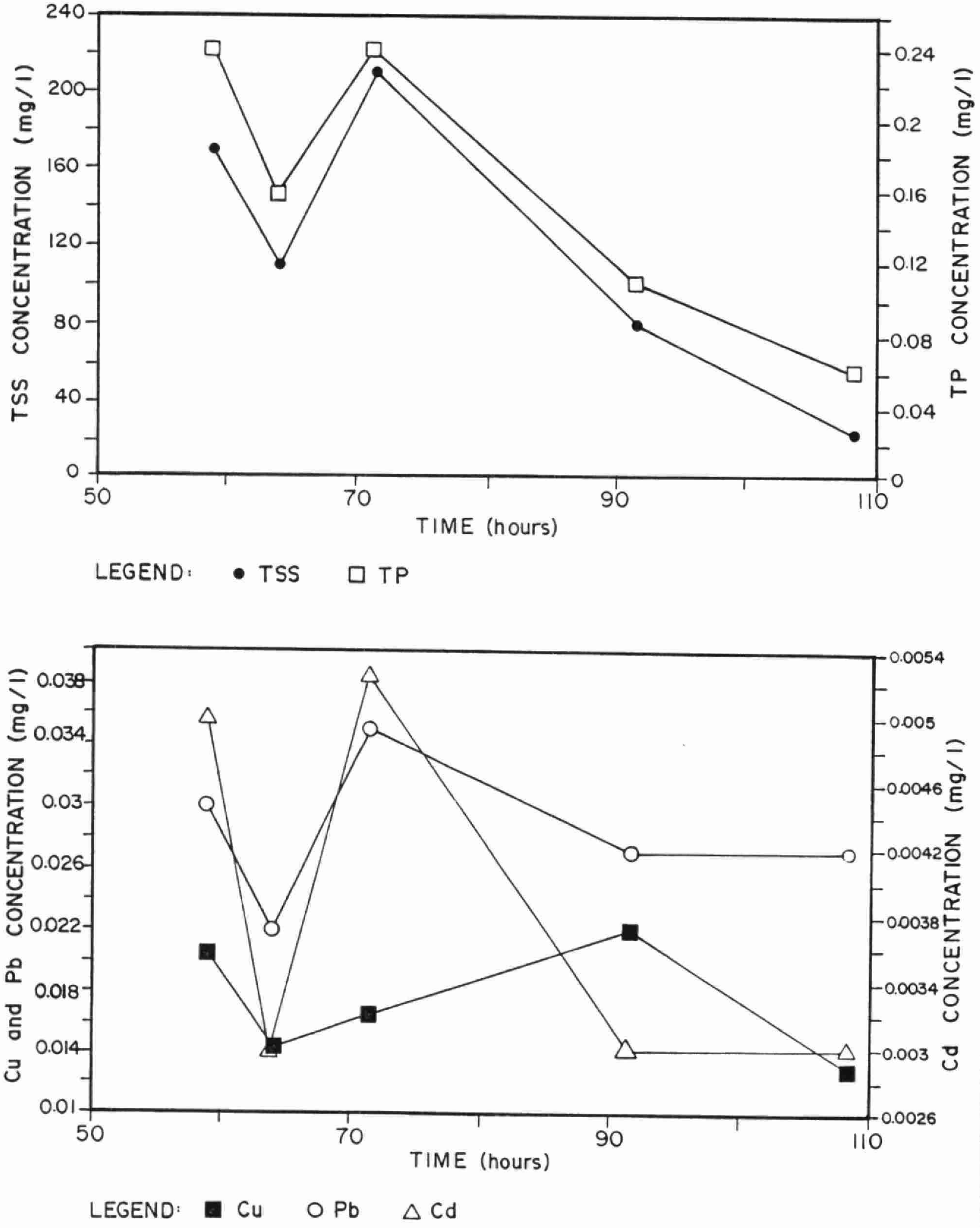
SAMPLING STATION H-14
WET EVENT POLLUTOGRAPHS

FIGURE: 3.5



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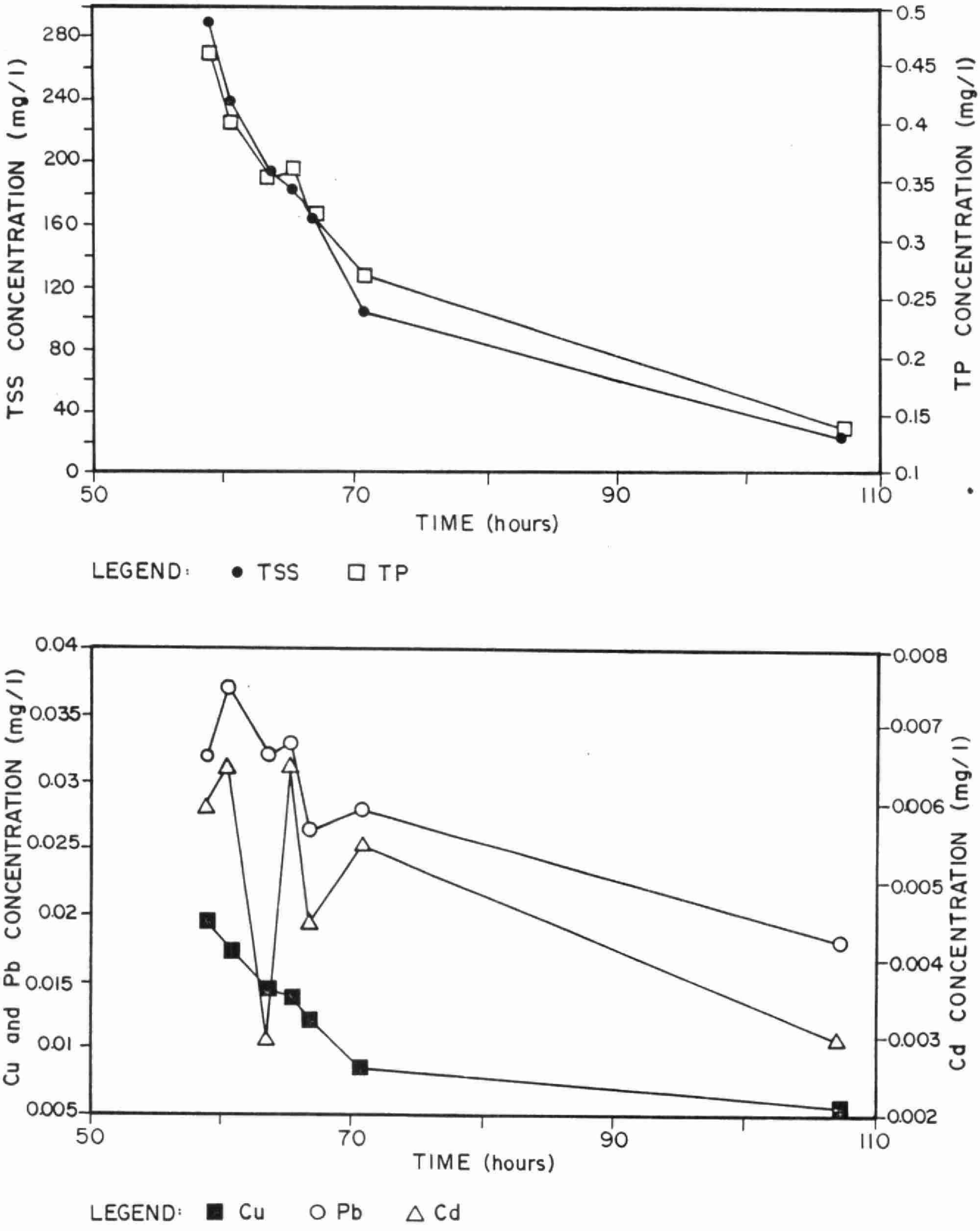
SAMPLING STATION E-8
WET EVENT POLLUTOGRAPHS

FIGURE: 3.6



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SAMPLING STATION W-6
WET EVENT POLLUTOGRAPHS

FIGURE: 3.7

concentrations of TSS, TP, Cu, Pb and Cd all preceded the hydrographic peak by at least 10 hours. This suggests that, in terms of contaminant inputs at station W-6, the initial runoff period is of greatest significance.

It is interesting to note the close association of TSS and TP in all of the examples. The implication is that phosphorus is largely sediment-transported. A similar association may exist between TSS and metals, however, the pollutographs indicate that some departures from this occur.

3.5 Subbasin Chemical Loadings

For each event the chemical contributions (i.e. discharge (Q), TSS, TP, Cu, Pb, Cd) of the subbasins were displayed on schematic diagrams of the Upper Humber watershed. Subbasin chemical contributions were represented as percentages of the loadings at the "mouth" of the Upper Humber watershed, the "mouth" being defined as the southern-most boundary of the study area. As the confluence of the West Humber River with the Humber River is downstream of the study area boundary (Figure 2.1) it was necessary to consider the West Humber separately from the Humber and East Humber Rivers. Therefore, subbasin chemical loadings were expressed as a percentage of the loading at Highway 7 (station W-6) for the West Humber River stations, and as a percentage of the loading at Steeles Avenue (station H-17) for all other stations. Obviously it was possible in some instances for the subbasin loadings of certain parameters to exceed those ocurring at the "mouth". In those cases the subbasin loading percentages were recorded as values greater than 100%.

For some events, metals concentrations at H-17 or W-6 were less than the detection limit. Because such concentrations are reported as zeros, no relative subbasin contributions could be calculated as the percentages would have undefined values. When applicable, these situations were identified on the schematic diagrams by asterisks at H-17 or W-6.

Chemical loadings by subbasin are presented in Figures 3.8 to 3.12 and Tables 3.12 to 3.16 and are discussed below.

Total Suspended Solids

Dry weather TSS contributions were minimal from the Humber River upstream of the Albion Hills. Although subbasin H-6 accounted for just over 50% of the Upper Humber River's dry weather discharge, it contributed less than 15% of the TSS load. Similarly, the tributaries "Coffey Creek" (H-4(T)), Centreville Creek (H-55(T)), and Cold Creek (H-10(T)) contributed little to the total TSS load. In Dry Events 1 and 2 there was an increase in TSS loading through the town of Bolton, although this trend was reversed in Dry Event 3. The greatest dry weather contributions of TSS occurred downstream of Bolton within subbasins H-11, H-14, and especially H-15. The East Humber River acted as relatively clean dilution for the Humber River at Woodbridge.

Relative to the Humber River, the West Humber River's dry weather discharge is minimal (<10% of the Humber River's discharge); the river becomes intermittent in summer. The West Humber River upstream of subbasin W-15 contributed virtually nothing to the system in dry weather. In terms of TSS, "Gore Creek" (subbasins W-5(T) and W-10(T)) likewise contributed minimally in dry weather.

Relative subbasin contributions of the Humber River did not change appreciably during the wet portion of Dry Event 2. On the West Humber River, however, there was a marked increase in the relative TSS loading of subbasin W-5(T).

During the Wet Event there was an increase in the relative

Table 3.12 **Mean Instantaneous Loadings - Dry Event 1.**

Station	Cumulative Drainage Area (km²)	Discharge (m³/s)	Parameter TSS ($x10^{-6}$kg/s)	TP ($x10^{-6}$kg/s)	Cu ($x10^{-6}$kg/s)	Pb ($x10^{-6}$kg/s)	Cd ($x10^{-6}$kg/s)
H-17	540	1.41	36067	84.8	15.1	26.4	No Data Available
H-15	290	1.07	43229	70.8	12.6	19.3	"
H-14	281	1.12	27000	64.0	21.0	21.0	"
H-11	268	1.13	30977	60.5	13.2	20.7	"
H-10(T)	63	0.24	1927	14.4	3.04	4.09	"
H-9	188	0.88	22168	58.8	13.0	14.2	"
H-75	177	0.77	7556	34.2	13.7	13.5	"
H-6	146	0.85	4278	42.8	21.2	14.6	"
H-55(T)	44	0.16	1264	8.26	2.24	2.58	"
H-4(T)	23	0.16	827	6.59	2.24	2.72	"
E-8	194	0.56	2992	26.2	9.33	11.3	"
E-7(T)	35	0.077	2549	4.64	0.87	1.68	"
E-6	141	0.14	2833	10.4	0.90	2.63	"
E-4	95	0.18	3721	12.4	2.18	3.81	"
W-6	143	0.088	2460	5.90	1.78	1.65	"
W-5(T)	59	0.020	108	1.52	0.29	0.35	"
W-10(T)	21	0.028	119	1.85	0.41	0.50	"
W-15	32	0.0037	10.0	0.073	0.069	0.056	"

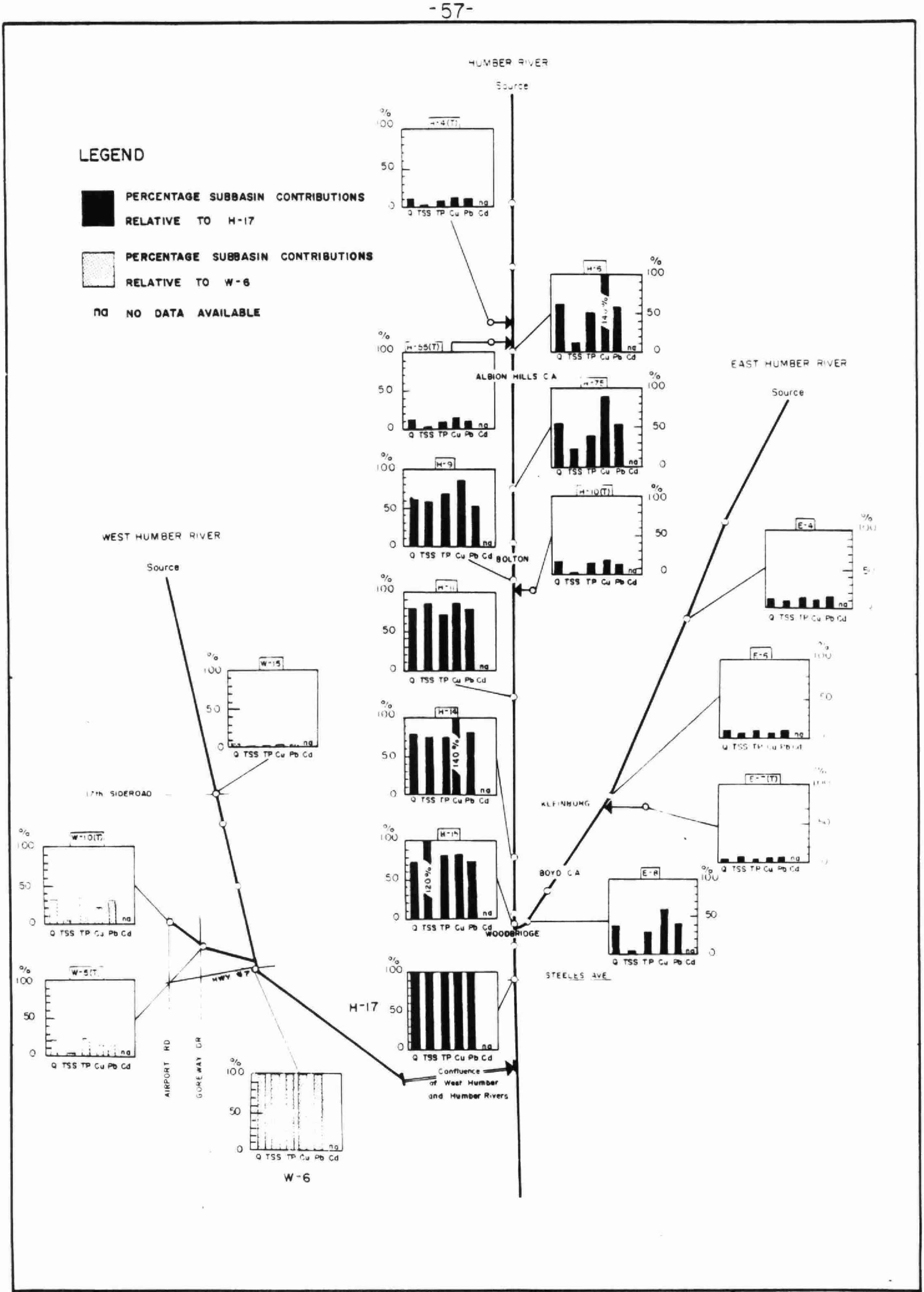


FIGURE 3.8

the metropolitan toronto and region conservation authority

MINISTRY OF THE ENVIRONMENT

TORONTO AREA WATERSHED MANAGEMENT STUDY 85

UPPER HUMBER RIVER STUDY

CHEMICAL LOADINGS BY SUBBASIN
DRY EVENT I

FIGURE 3.8

MARCH 1985

2 0 2 km

Table 3.13 **Mean Instantaneous Loadings - Dry Event 2.**

			Parameter				
Station	Cumulative Drainage Area (km²)	Discharge (m³/s)	TSS ($\times 10^{-6}$kg/s)	TP ($\times 10^{-6}$kg/s)	Cu ($\times 10^{-6}$kg/s)	Pb ($\times 10^{-6}$kg/s)	Cd ($\times 10^{-6}$kg/s)
H-17	540	1.22	34800	66.6	9.47	29.4	0.00
H-15	290	0.97	41299	82.4	8.31	18.5	0.50
H-14	281	1.01	37100	59.0	11.0	26.0	0.25
H-11	268	0.98	23628	59.2	6.63	22.7	0.49
H-10(T)	63	0.22	1220	4.63	1.82	5.64	0.11
H-9	188	0.85	14091	38.8	18.6	22.2	0.00
H-75	177	0.77	4252	23.6	7.73	18.6	0.00
H-6	146	0.69	3105	20.0	9.14	21.4	0.34
H-55(T)	44	0.17	1276	5.85	2.29	5.80	0.21
H-4(T)	23	0.13	976	3.84	1.14	4.57	0.16
E-8	194	0.46	2295	9.78	2.63	23.7	0.23
E-7(T)	35	0.073	584	1.02	0.74	3.14	0.055
E-6	141	0.33	1102	2.45	1.21	3.66	0.082
E-4	95	0.073	292	1.63	0.83	2.71	0.037
W-6	143	0.080	1680	4.16	0.56	2.64	0.020
W-5(T)	59	0.024	23	0.41	0.26	0.92	0.030
W-10(T)	21	0.030	103	0.83	1.10	1.03	0.014
W-15	32	0.00	0.00	0.00	0.00	0.00	0.00

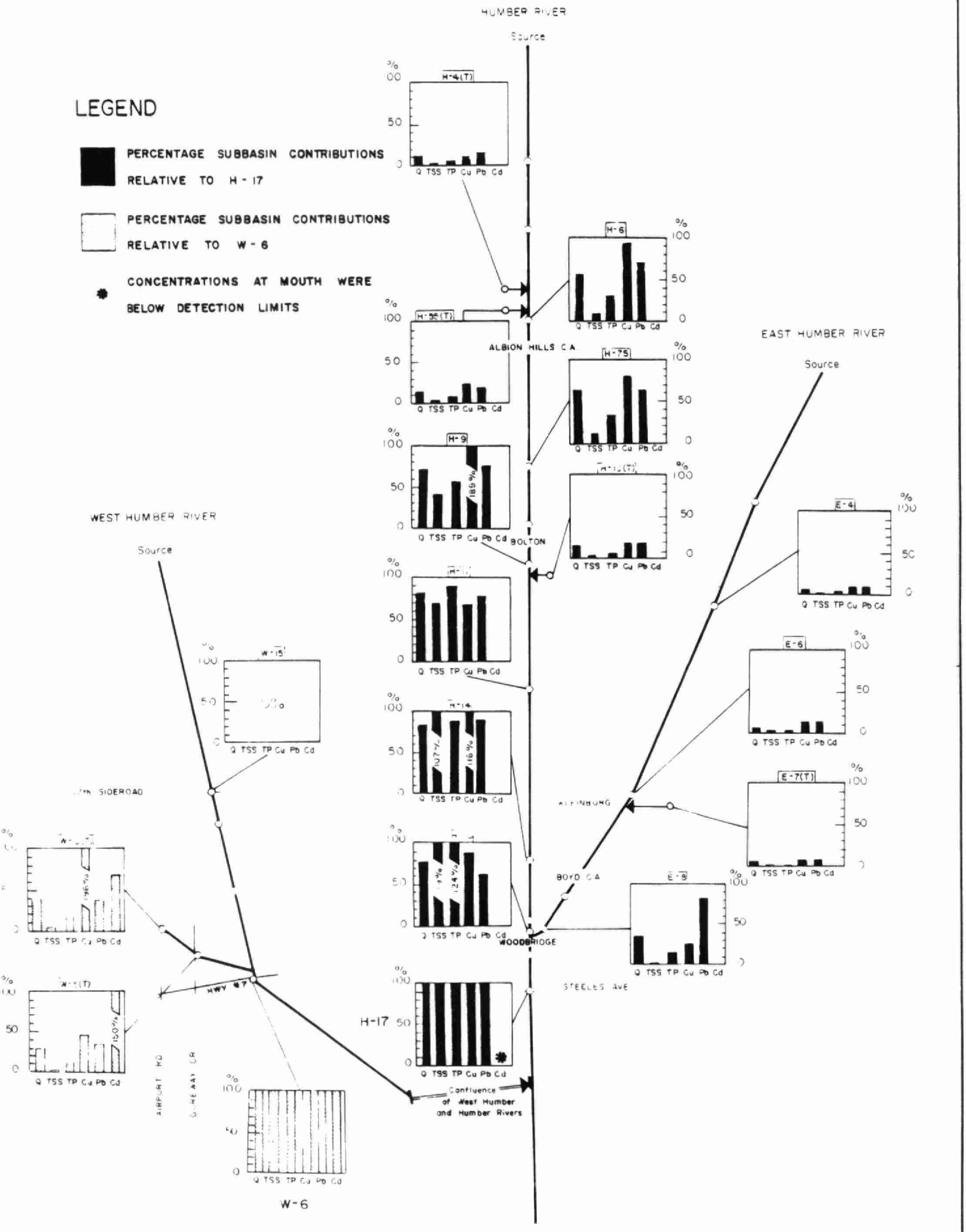
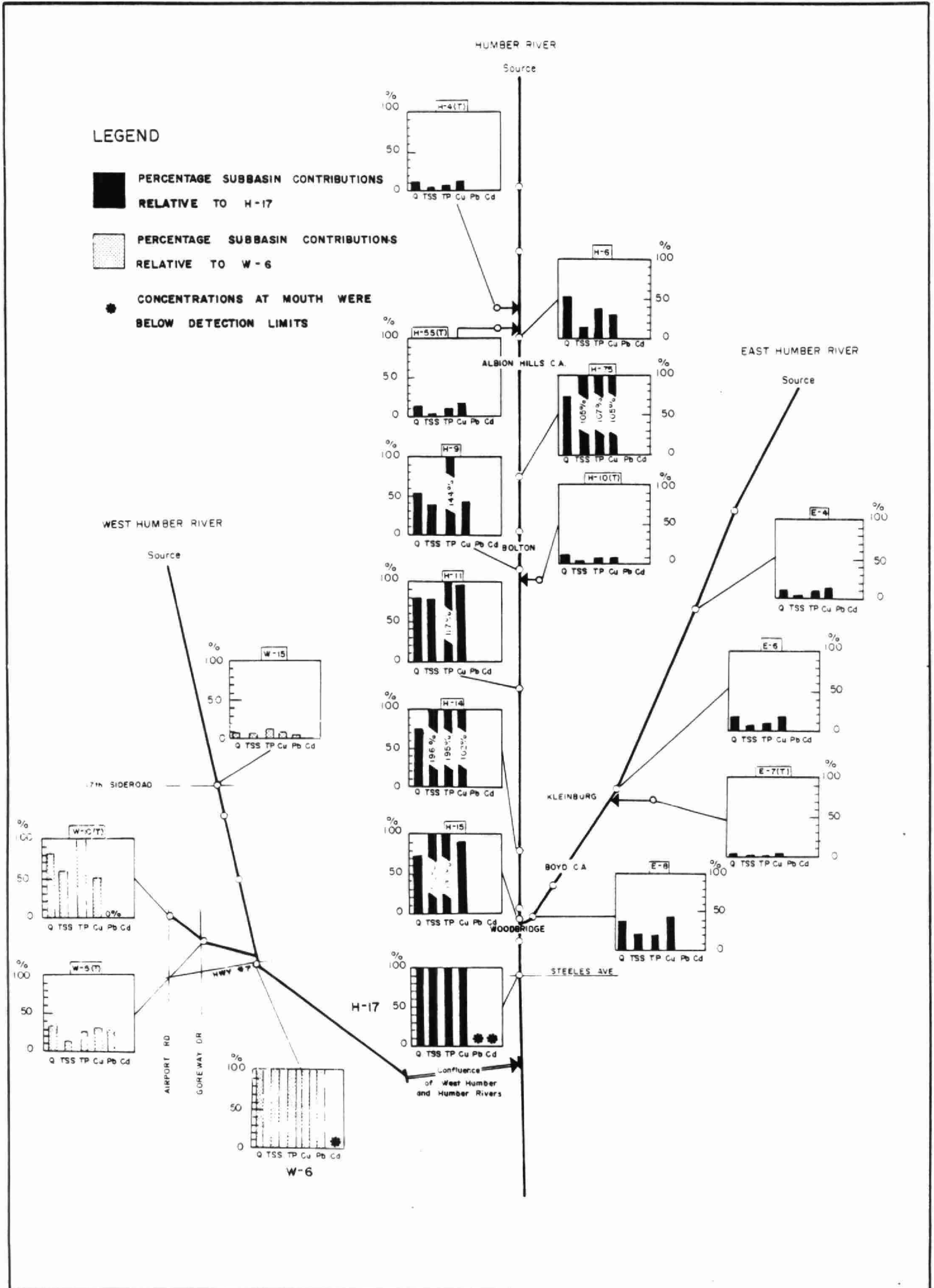


FIGURE 3.9	the metropolitan toronto and region conservation authority MINISTRY OF THE ENVIRONMENT TORONTO AREA WATERSHED MANAGEMENT STUDY 85	UPPER HUMBER RIVER STUDY CHEMICAL LOADINGS BY SUBBASIN DRY EVENT 2 (DRY PORTION)	FIGURE 3.9 MARCH 1985 2 0 2 km

Table 3.14 **Mean Instantaneous Loadings - Dry Event 3.**

	Parameter						
Station	Cumulative Drainage Area (km²)	Discharge (m³/s)	TSS ($\times 10^{-6}$kg/s)	TP ($\times 10^{-6}$kg/s)	Cu ($\times 10^{-6}$kg/s)	Pb ($\times 10^{-6}$kg/s)	Cd ($\times 10^{-6}$kg/s)
H-17	540	2.36	23512	40.9	3.95	0.00	0.00
H-15	290	1.76	28676	54.2	3.59	0.00	0.00
H-14	281	1.76	46100	80.0	4.00	0.00	0.00
H-11	268	1.88	18591	47.6	3.77	0.00	0.00
H-10(T)	63	0.30	1082	3.43	0.30	0.00	0.00
H-9	188	1.24	9014	59.4	1.63	0.00	0.00
H-75	177	1.78	24738	43.8	4.14	0.00	0.00
H-6	146	1.25	3030	16.3	1.25	0.00	0.00
H-55(T)	44	0.30	757	4.09	0.60	0.00	0.00
H-4(T)	23	0.27	730	2.87	0.45	0.00	0.00
E-8	194	0.92	4723	8.26	1.84	0.00	0.00
E-7(T)	35	0.10	482	0.52	0.17	0.00	0.00
E-6	141	0.43	1818	4.13	0.73	0.00	0.00
E-4	95	0.26	767	4.16	0.53	0.00	0.00
W-6	143	0.26	1126	2.64	0.81	0.64	0.00
W-5(T)	59	0.090	155	0.66	0.27	0.19	0.00
W-10(T)	21	0.21	659	2.60	0.41	0.00	0.00
W-15	32	0.022	80.9	0.33	0.066	0.033	0.00



3.10 FIGURE

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MINISTRY OF THE ENVIRONMENT

TORONTO AREA WATERSHED MANAGEMENT STUDY 85

UPPER HUMBER RIVER STUDY

CHEMICAL LOADINGS BY SUBBASIN
DRY EVENT 3

FIGURE 3.10

MARCH 1985

2 1 0 1 2 km

Table 3.15 Mean Instantaneous Loadings - Dry Event 2 (wet portion)

Station	Cumulative Drainage Area (km^2)	Discharge (m^3/s)	TSS ($x10^{-6}kg/s$)	TP ($x10^{-6}kg/s$)	Cu ($x10^{-6}kg/s$)	Pb ($x10^{-6}kg/s$)	Cd ($x10^{-6}kg/s$)
			Parameter				
H-17	540	3.62	15747	11.8	0.90	2.53	0.22
H-15	290	3.48	19894	6.94	0.90	2.55	0.19
H-14	281	3.24	14170	15.6	0.74	2.20	0.19
H-11	268	2.34	9710	12.0	0.69	1.95	0.18
H-10(T)	63	0.39	221	0.35	0.038	0.15	0.010
H-9	188	1.91	2490	2.74	0.23	0.78	0.049
H-75	177	1.71	510	1.18	0.16	0.62	0.0086
H-6	146	1.78	617	1.43	0.16	0.66	0.030
H-55(T)	44	0.44	33.9	0.36	0.058	0.15	0.00
H-4(T)	23	0.38	397	0.60	0.044	0.15	0.013
E-8	194	1.42	989	1.30	0.20	0.75	0.022
E-7(T)	35	0.40	2009	0.41	0.19	0.45	0.061
E-6	141	0.33	237	0.17	0.033	0.18	0.0038
E-4	95	0.31	184	0.14	0.043	0.18	0.0058
W-6	143	0.42	714	0.75	0.071	0.20	0.020
W-5(T)	59	0.15	396	0.38	0.059	0.076	0.016
W-10(T)	21	0.18	179	0.28	0.033	0.067	0.0054
W-15	32	0.018	1.24	0.0057	0.0034	0.0072	0.00014

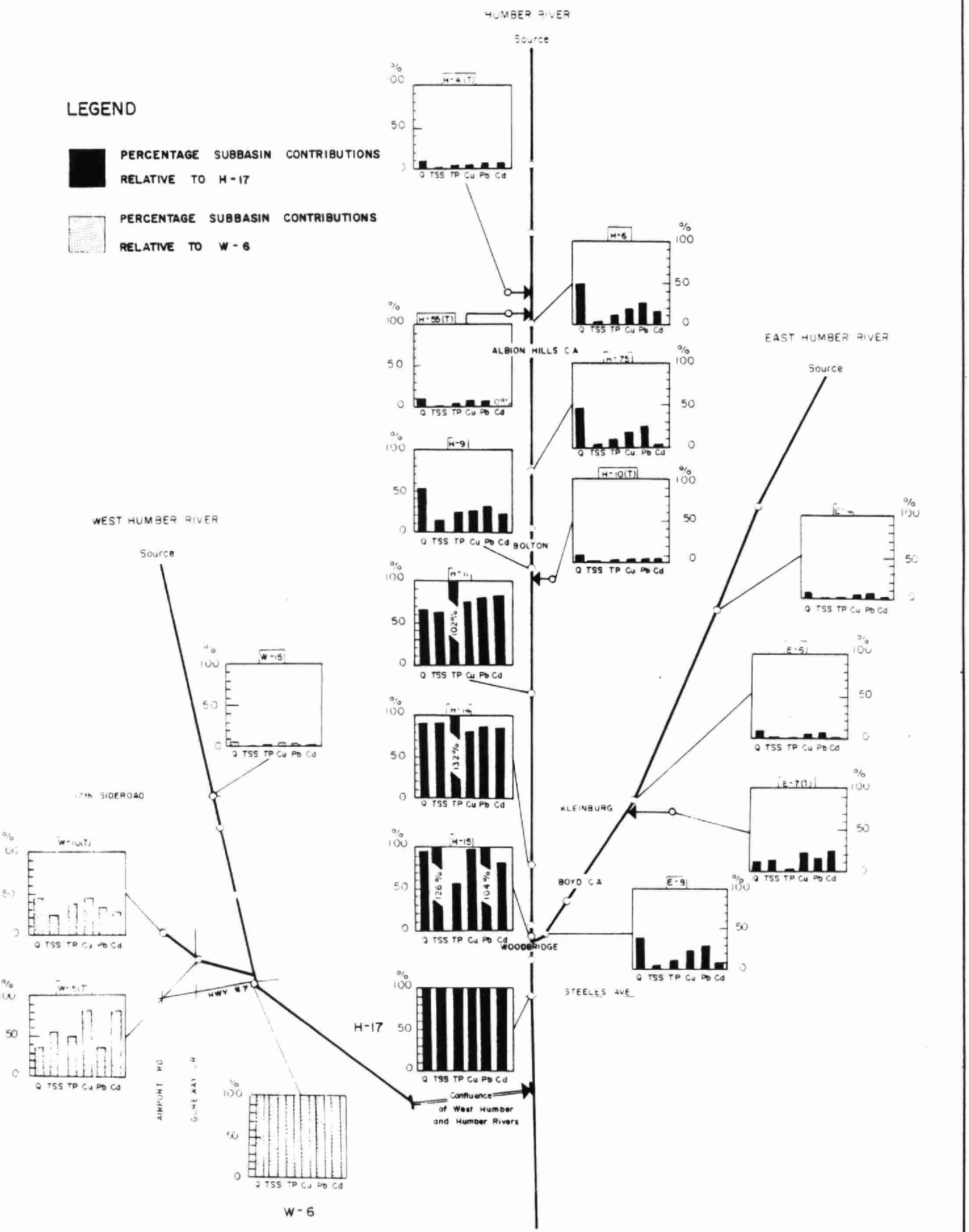

FIGURE 3.11

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MINISTRY OF THE ENVIRONMENT

TORONTO AREA WATERSHED MANAGEMENT STUDY 85

UPPER HUMBER RIVER STUDY

FIGURE 3.11

CHEMICAL LOADINGS BY SUBBASIN
DRY EVENT 2 (WET PORTION)

MARCH 1985

2 0 2 km

Table 3.16 Loads For Sampled Portion Of Wet Event

Station	Cumulative Drainage Area (km^2)	Water Volume ($x10^3m^3$)	TSS (kg)	TP (kg)	Cu (kg)	Pb (kg)	Cd (kg)
	Parameter						
H-17	540	1872	266379	436	18.0	59.2	8.79
H-15	290	856	133961	169	10.2	21.8	2.20
H-14	281	770	107135	157	16.0	22.1	3.86
H-11	268	924	182183	226	8.79	27.3	2.72
H-10(T)	63	99.6	3805	6.85	1.56	2.74	0.32
H-9	188	790	185143	208	7.76	27.7	3.14
H-75	177	688	114160	150	4.40	18.1	1.67
H-6	146	514	87513	126	6.52	16.5	1.64
H-55(T)	44	178	1488	6.36	1.35	3.33	0.36
H-4(T)	23	167	7789	13.7	2.18	3.93	0.40
E-8	194	490	59469	76.7	8.76	14.2	1.86
E-7(T)	35	215	37551	49.8	4.30	6.62	1.16
E-6	141	189	24922	31.3	1.32	5.24	0.50
E-4	95	211	15925	29.1	1.30	5.32	0.50
W-6	143	622	84545	195	6.87	19.4	3.54
W-5(T)	59	67.3	2618	13.2	1.49	1.66	0.18
W-10(T)	21	115	3407	12.9	0.73	2.77	0.30
W-15	32	136	13211	36.2	1.20	3.73	0.46

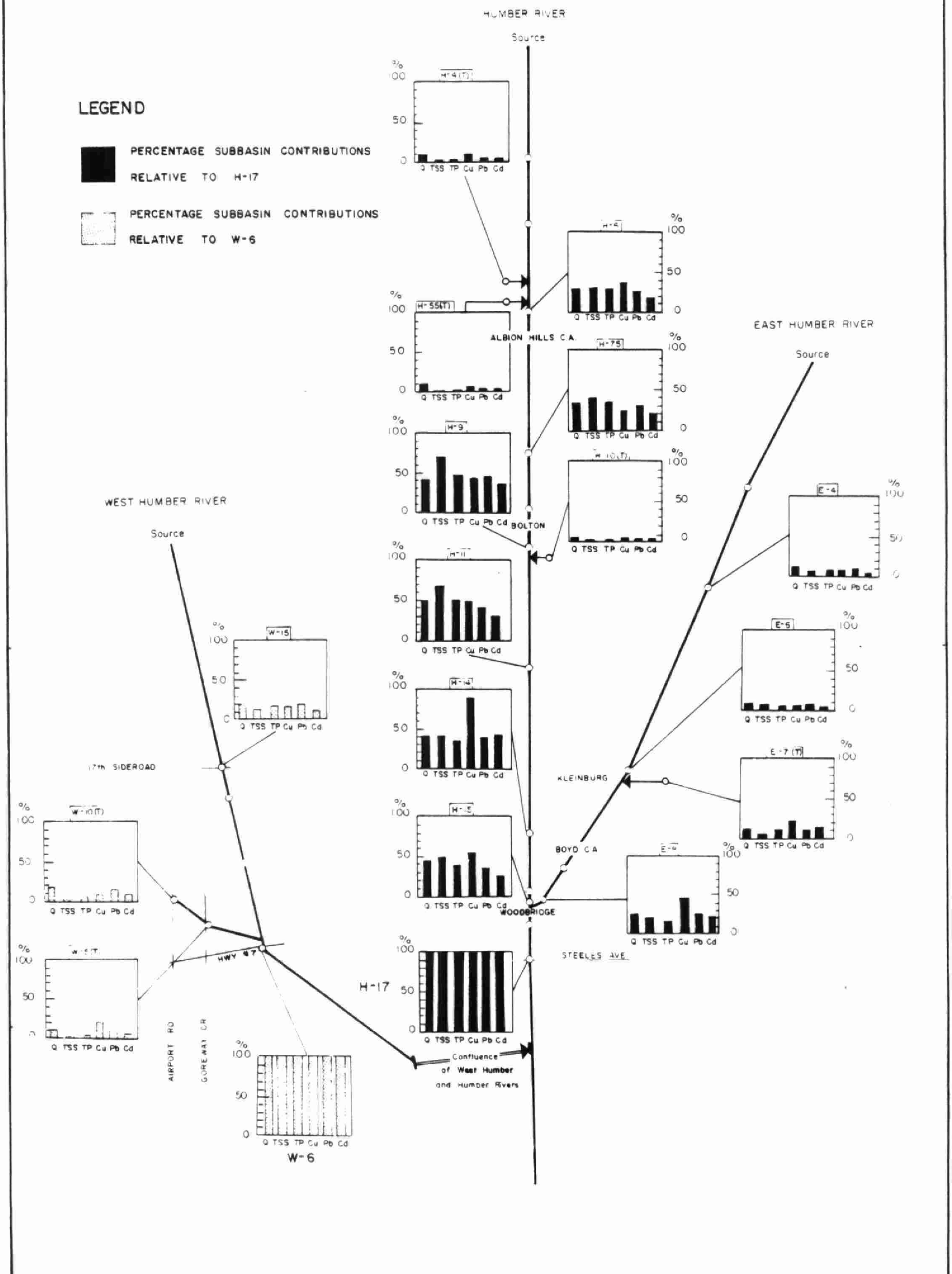

FIGURE 3.12

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MINISTRY OF THE ENVIRONMENT

TORONTO AREA WATERSHED MANAGEMENT STUDY 85

UPPER HUMBER RIVER STUDY

CHEMICAL LOADINGS BY SUBBASIN
WET EVENT

FIGURE 3.12

MARCH 1985

2 1 0 1 2 km

TSS contribution from the H-6 subbasin. Again there was an increase in TSS load through the town of Bolton, however the relative contributions of subbasins H-11, H-14, and H-15 were lower than in dry weather. In general, the Humber River upstream of Woodbridge accounted for a smaller proportion of the total discharge than it had in dry weather - only 50% in the wet event compared with 70 to 80% in dry weather. The relative contribution of the East Humber River to total discharge was also reduced. This indicates the increased importance of subbasin H-17 in the Wet Event. This trend was not evident in the wet portion of Dry Event 2, suggesting that there may be differences in the way the watershed responds to various storm events.

On the West Humber River, the major TSS inputs during the Wet Event occurred within the W-6 subbasin; as in dry weather, the other subbasins contributed relatively little to the total TSS load. The discharge of the West Humber River relative to the Humber River was substantially greater during the Wet Event than it had been in dry weather. In dry weather the discharge of the West Humber River was usually less than 10% of the Humber River's discharge, however in the Wet Event this percentage increased to 33%. Relative impacts of the two rivers on the lower Humber are hard to determine based on our data because the West Humber River passes through Claireville Reservoir between station W-6 and its confluence with the Humber River near Weston Road.

Total Phosphorus

Total phosphorus contributions varied considerably between Dry Events 1, 2 and 3. An exception to this were the relative loadings from the upstream Humber River tributaries H-4(T), H-55(T) and H-10(T), which were consistently low. In no dry event did the loadings from any of these subbasins exceed 20% of the loading at H-17. Unlike TSS, TP loadings from subbasin H-6 corresponded closely to stream discharge, approaching 50% of the TP loading at H-17 during Dry Events 1 and 3. Loadings were slightly lower during the second event. Under all dry event conditions, the TP loadings increased between stations H-75 and H-9 (i.e. through the town of Bolton). During each event, the relative loadings increased about 30%; from 35 to 65% of the loading at Steeles Avenue during Dry Events 1 and 2 and from 107 to 144% during Dry Event 3. Of note is the fact that these TP increases were not accompanied by any appreciable increases in stream discharge, suggesting TP inputs were of a concentrated point source nature.

During dry weather conditions, relative TP contributions from subbasins through the central and southern portions of the Humber River (i.e. H-11, H-14 and H-15) ranged from 75 to 195% of the levels at H-17. The latter contribution occurred from the H-14 subbasin during Dry Event 3. Comparatively speaking, total phosphorus loadings from these subbasins generally exceeded corresponding stream discharges relative to values at H-17.

Total phosphorus inputs from the East Humber River subbasins were comparatively small relative to the loadings at Steeles Avenue. The most significant contribution occurred from the E-8 subbasin during Dry Event 1, when the TP loading was about 30% of the value at H-17.

Dry weather TP contributions from subbasins on the West Humber River were generally small relative to the loading at W-6. An exception occurred from the W-10(T) subbasin during Dry Event 3, when TP loading was equal to the loading at W-6.

Certain loading trends noted during the Dry Events were also seen during wet weather conditions. For example, the relative TP contributions from the tributary subbasins H-4(T), H-55(T) and H-10(T) were also minimal during wet weather sampling. Similarly, increases in the relative TP loadings through the town of Bolton were observed during both the wet portion of Dry Event 2 and the Wet Event, although they were not as dramatic as those which occurred during the dry events. Differences in TP loadings from the H-11, H-14 and H-15 subbasins were apparent between the two wet weather sampling periods. Relative to H-17, the more significant contributions from these subbasins occurred during the wet portion of Dry Event 2.

Typically, wet weather TP loadings were relatively small from the East Humber River subbasins. Subbasin contributions were generally less than 10% of the value at H-17, increasing to about 20% at station E-8, near Woodbridge. Relative to station H-17, the discharge contribution from most East Humber River subbasins exceeded the corresponding TP contribution.

On the West Humber River during the wet portion of Dry Event 2, the most significant TP contributions occurred from the W-10(T) and W-5(T) subbasins, with respective loadings of 40 and 50%, relative to the value at W-6. During the Wet Event, relative TP contributions from these subbasins were much smaller.

Copper

In Dry Events 1 and 2, Cu loadings at H-6, the chemical sampling station closest to the source on the Humber River, had already reached the levels of the Humber River at Steeles Avenue. Although this was not the case in Dry Event 3, high loadings were found at the next station downstream, station H-75. The relative Cu contributions of the tributaries H-4(T), H-55(T), and H-10(T) in the three dry events were generally equal to their relative discharge contributions. The same was the case for most of the East Humber River, however, in the lower, E-8 subbasin, relative Cu loadings tended to exceed relative discharges suggesting that subbasin E-8 could be a Cu source.

On the West Humber River, contributions of subbasin W-15 were minimal. Subbasins W-5(T) and especially W-10(T) had relatively high Cu contributions in Dry Event 2.

In wet weather, the relative Cu contributions from the upper portions of the Humber River were not as high as they had been in dry weather. In the wet portion of Dry Event 2, Cu loadings did not reach the level of Steeles Avenue until subbasin H-11. In the Wet Event, this occurred even further downstream, in subbasin H-14, however, relative loadings then decreased in subbasin H-15. Subbasin E-7(T) had a high Cu contribution in wet weather relative to its discharge. Wet Event Cu loadings at station E-8 reached nearly 50% of the Cu loading at station H-17.

There were high Cu contributions from subbasins W-5(T) and W-10(T) during the wet portion of Dry Event 2, however, this was not the case in the Wet Event. In the Wet Event, the bulk of the West Humber River's Cu load came from subbasin W-6.

Lead

The relative Pb contributions from subbasins throughout the study area were very similar during Dry Events 1 and 2. From almost every subbasin the loadings closely paralleled stream discharge, possibly suggesting inputs were generally of a diffuse nature.

Within the Humber River watershed, loadings from the tributaries H-4(T), H-55(T) and H-10(T) were minimal. Between stations H-6 in the Albion Hills and H-14 in the lower stretches, loadings were typically between 60 and 85% of the loading at Steeles Avenue.

On the East Humber River, relative subbasin contributions were generally smaller due to lower stream discharges. An exception occurred from the E-8 subbasin near Woodbridge, where Pb loading was 40% of the value at H-17 during Dry Event 1 and 80% during Dry Event 2. This relative subbasin loading during Dry Event 2 is noteworthy because the corresponding stream discharge was only 40% and, thus, this is the only instance when Pb loading varied appreciably from discharge during either Dry Events 1 or 2.

On the West Humber River, the relative Pb contribution during Dry Events 1 and 2 was minimal from the W-15 subbasin. From subbasins W-10(T) and W-5(T), the respective loadings averaged 35 and 25% of the loading at W-6.

During Dry Event 3, all Pb levels in the Humber and East Humber Rivers were below the detection limit and, therefore, no relative parameter loadings could be determined for these rivers.

On the West Humber River, during Dry Event 3, the relative Pb loading was minimal from subbasin W-15. At W-10(T) the Pb concentration was 0 mg/l, despite a comparatively large proportion of stream discharge (80%), relative to W-6. Lead loading from subbasin W-5(T) was about 30% of the value at W-6.

As was the case with Cu loadings, relative Pb contributions from subbasins during wet weather conditions were generally not as high as had been noted during dry weather. This may suggest that dry weather sources of Pb become diluted during wet weather conditions. Relative Pb loadings during the wet portion of Dry Event 2 were similar to those occurring during dry weather conditions in that they generally corresponded to stream discharge. The exceptions occurred in the upper reaches of the Humber River, where the relative Pb contributions from subbasins H-6, H-75 and H-9 were only about 30% of the value at H-17, while the corresponding stream discharges were about 50%.

During the Wet Event, it appeared that a large proportion of the Pb loading was contributed by the H-17 subbasin itself. The relative Pb contribution at station H-15 on the Humber River was only 37% of the value at Steeles Avenue, and at station E-8 on the East Humber River, the relative loading was 24%. Stream discharges were correspondingly low suggesting that during severe storm events the relative contributions from the H-17 subbasin can be significant.

Relative to station W-6, the percentage contributions from the other subbasins on the West Humber River (W-15, W-10(T) and W-5(T)), were lower during the Wet Event than those recorded during Dry Events 1 and 2 (dry and wet portion).

Cadmium

No Cd data were available for Dry Event 1. For Dry Event 2 the Cd concentration at H-17 was below the detection limit and, therefore, relative subbasin loadings could not be represented on the schematic diagram. Loadings were calculated for stations having detectable Cd concentrations; these loadings are shown in Table 3.13. The highest Cd loading was recorded from station H-15. On the West Humber system, "Gore Creek", represented by subbasins W-5(T) and W-10(T), accounted for most of the Cd loading in Dry Event 2. In Dry Event 3, concentrations were less than the detection limit at all stations.

In the wet portion of Dry Event 2 the greatest increase in Cd loading on the Humber River occurred within subbasin

H-11. "Kortright Creek" (subbasin E-7(T)), tributary to the East Humber River, also seemed to be a significant Cd source considering this tributary's relatively small drainage area (Table 3.15). As noted for some other parameters, in the Wet Event subbasin H-17 had a high contribution to the total event load of Cd - no other Humber or East Humber subbasin's contribution represented greater than 45% of the total Cd load. On the West Humber River there were similar differences between the wet portion of Dry Event 2 and the Wet Event. Subbasins W-5(T) and W-10(T), although representing the bulk of the Cd loading in the wet portion of Dry Event 2, had relatively smaller contributions in the Wet Event.

3.6 **Bed Sediment Chemistry**

All but one of the 19 sediment samples collected from stations in the Upper Humber watershed were classified as very fine sand based on grain size analysis. Station W-5(T) was classified as medium to coarse sand. Figure 3.13 shows the percentage by weight of very fine sand in the sediments collected at each station. At all stations except W-5(T), very fine sand was the dominant grain size. Silts and clays represented less than 3% by weight at all stations.

Loss on ignition (LOI), an estimate of organic content, ranged from 2.1 to 13.6% (mean 6%). The highest values occurred at stations located in the upper reaches of the watershed (i.e. W-15, W-10(T), E-2, H-4(T), H-55(T) and H-6) and values generally decreased at downstream stations. Loss on ignition levels at the above noted stations exceeded the guideline of 6% for sediments suitable for open water disposal (MOE 1976a, 1978).

Cadmium concentrations were less than the detection limit (1.0 mg/kg) at all stations, and were therefore excluded from all subsequent analyses. Basic statistical analyses

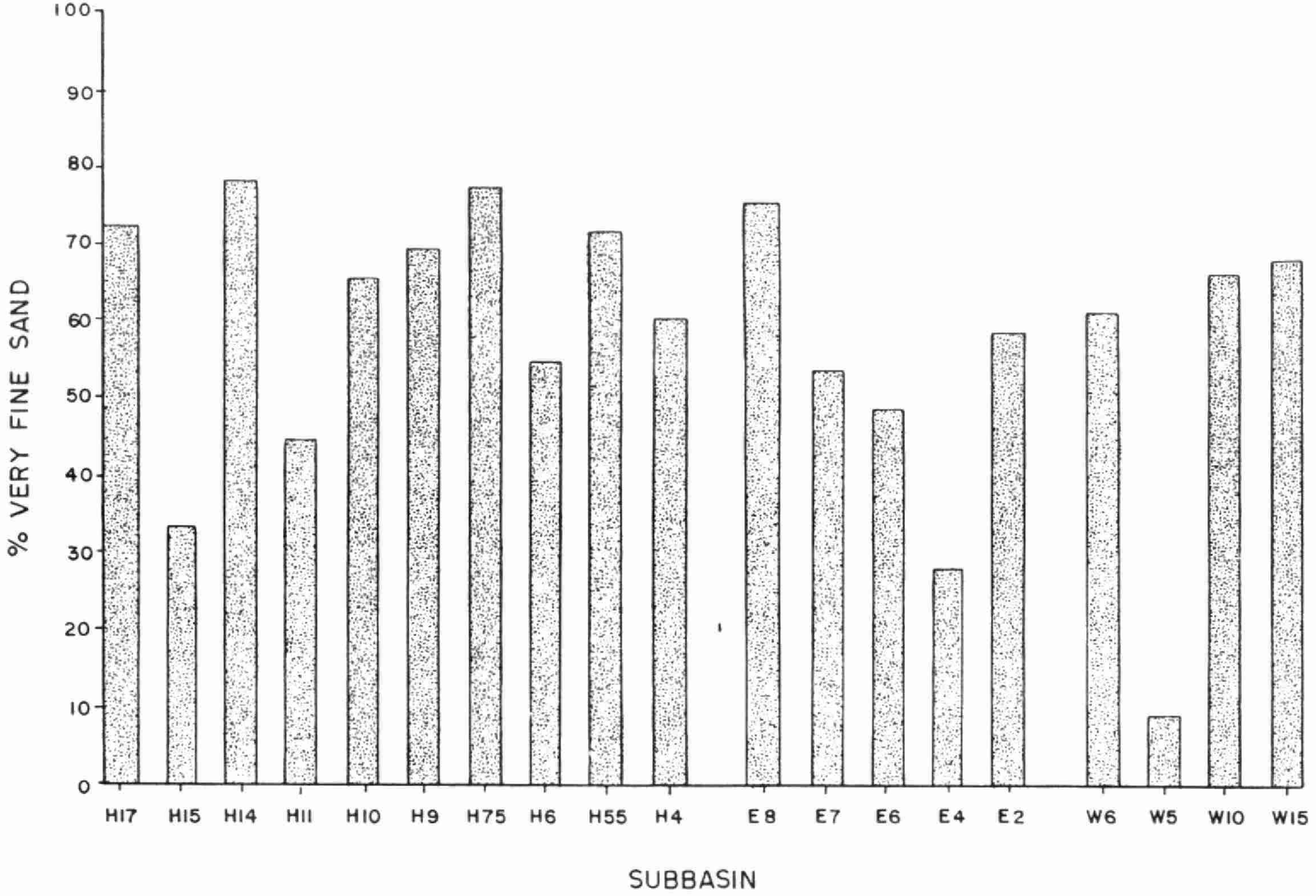

FIGURE 3.13

the metropolitan toronto and region conservation authority

MOE - TAWMS 85

UPPER HUMBER RIVER STUDY

BED SEDIMENTS - VERY FINE SAND FRACTION

FIGURE: 3.13

MARCH 1985

were performed on the remaining chemical data and the results are as follows:

	Mean	Minimum	Maximum
TP(mg/kg)	245	25 @ H-9	850 @ W-10(T)
Cu(mg/kg)	17	6 @ H-11, E-4	38 @ W-10(T)
Pb(mg/kg)	16	4 @ E-4	48 @ W-10(T)
Zn(mg/kg)	61	30 @ E-4	104 @ E-8

The distribution of TP, Cu, Pb and Zn by station is shown in Figure 3.14. Stations were divided into two arbitrary groups; those with "low" concentrations and those with "high" concentrations as follows:

TP: > 300 mg/kg @ H-14, H-9, H-55(T), W-10(T), W-15
< 100 mg/kg @ H-17, H-11, E-6, E-4, W-6
Zn: > 65 mg/kg @ H-9, H-55(T), E-8, E-2, W-10(T)
< 35 mg/kg @ H-11, E-4, W-5(T)
Cu,Pb: > 20 mg/kg @ H-17, H-9(Pb only), E-8, E-2, W-10(T)
< 10 mg/kg @ H-11, H-75, H-9(Pb only), E-4

With only two exceptions, contaminant levels were not in exceedance of the MOE's open water disposal guidelines (MOE 1976a, 1978). Exceptions occurred at stations E-8 and E-2, where the Zn concentration exceeded the guideline of 100 mg/kg.

Three groups of variables were positively correlated ($p<0.05$) as follows:

1) Zn, Pb, Cu, and silt.
2) Zn, TP, and LOI.
3) TP, and very fine sand.

Four groups of variables were negatively correlated ($p<0.05$) as follows:

1) Very fine sand, medium sand, coarse sand, and very coarse sand.

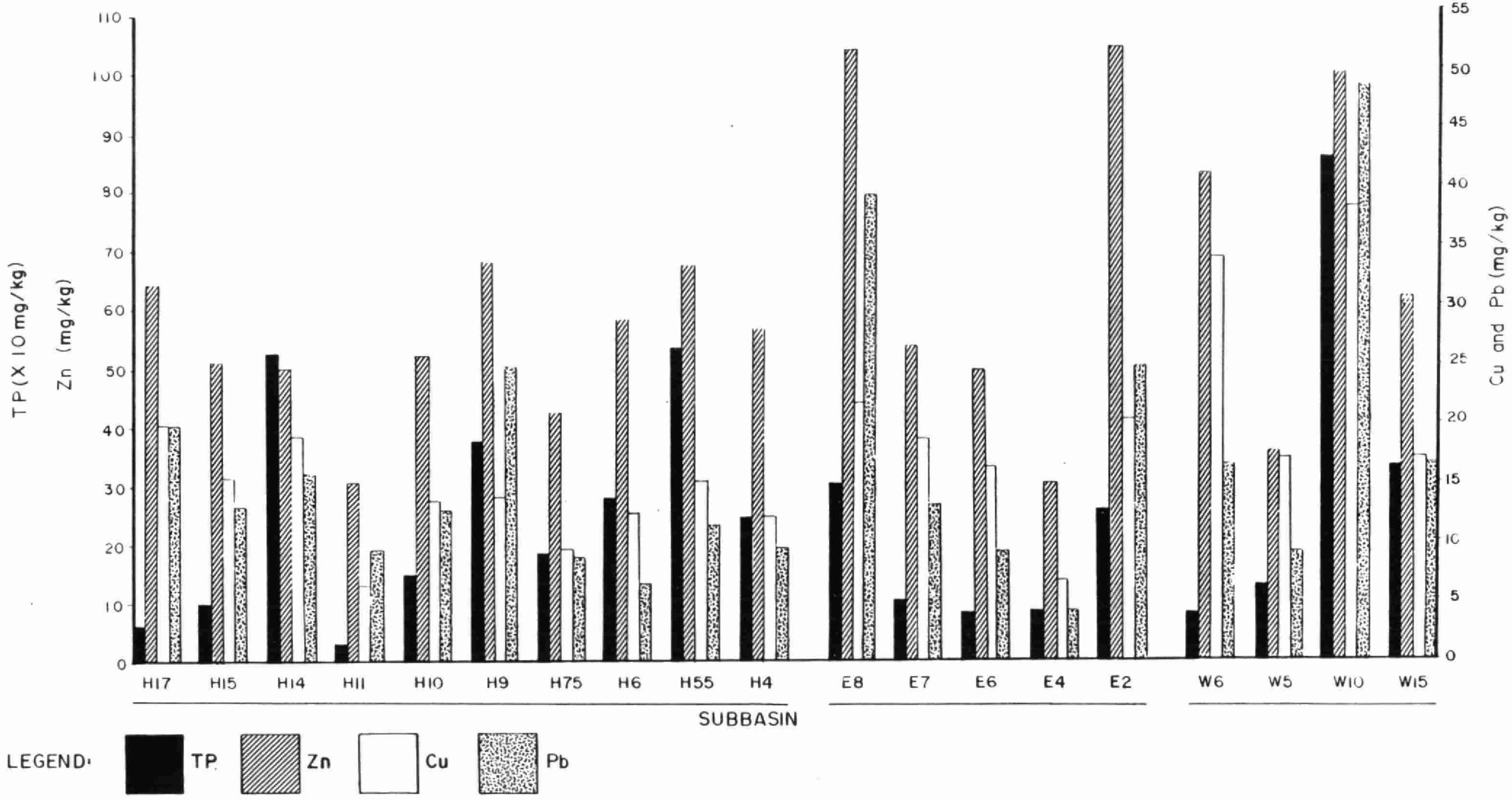

FIGURE: 3.14

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MINISTRY OF THE ENVIRONMENT

TORONTO AREA WATERSHED MANAGEMENT STUDY - TAWMS 85

UPPER HUMBER RIVER STUDY

BED SEDIMENTS - CHEMICAL CONCENTRATIONS

FIGURE: 3.14

MARCH 1985

2) Coarse sand, very coarse sand, and TP.
3) Silt, medium sand, and very coarse sand.
4) Medium sand, very coarse sand, Pb, and Zn.

In general, these correlations suggest that fluctuations in concentrations of metals and TP parallel fluctuations in the proportion of silt and very fine sand respectively. Also, comparatively high concentrations of Zn and TP are found in sediment of high organic content. Lead and Cu do not exhibit this positive association with organic content.

Complete bed sediment data and the results of the correlation analysis are presented in Appendix 4.

3.7 Land Use

Crop farming (Agriculture) forms the major proportion of land use within the Upper Humber study area. This land use presently comprises 69%, 81% and 87% of the Humber, East Humber and West Humber River basins respectively (Figure 3.15).

Within the Humber River watershed, pasture land (Pasture) tends to predominate in the more northerly subbasins (i.e. H-20, H-2, H-4(T), H-55(T) and H-6). This is likely because of the extremely hummocky terrain in this region which is better suited for livestock grazing than for crop farming. The shift from predominantly pasture land to agricultural land is dramatic as the Humber River exits the Oak Ridges Moraine and begins to flow over the more gently sloping till plain. From subbasin H-75 south to H-17 the agricultural component within each subbasin is typically between 45 to 75%. The proportion of Forested area within each subbasin is fairly consistent, averaging about 15%. The major Urban

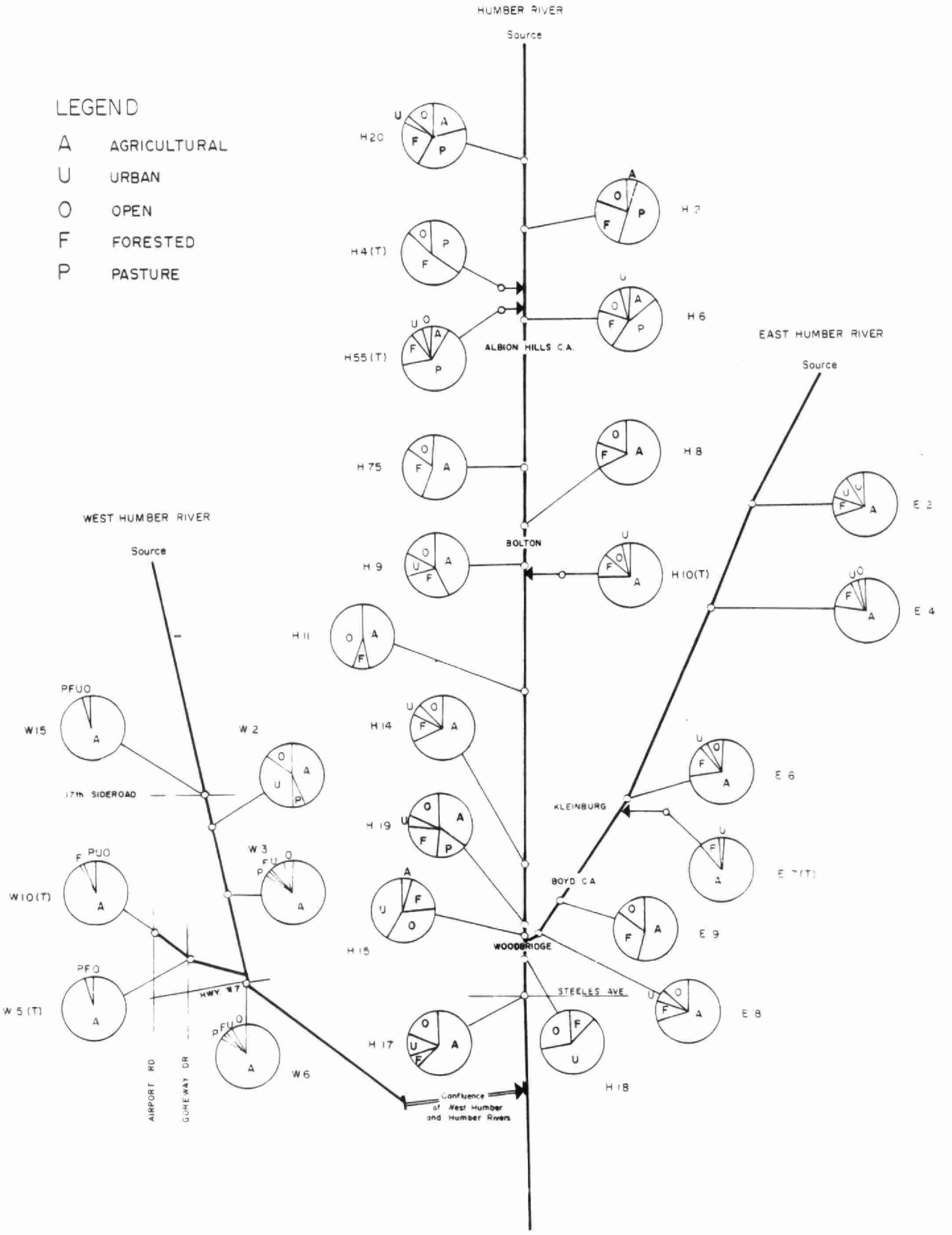

FIGURE 3.15

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TORONTO AREA WATERSHED MANAGEMENT STUDY 85

UPPER HUMBER RIVER STUDY

PERCENTAGE LAND USE
BY SUBBASIN

FIGURE 3.15

MARCH 1985

km 2 1 0 1 2

land use within the Humber River watershed is limited to subbasins encompassing Bolton and Woodbridge (i.e. H-8, H-9, H-19, H-15 and H-18).

Land use within the East Humber River basin parallels that of the Humber River although no significant pasture land was found. A fairly large urban component is present in the E-2 subbasin, due primarily to the communities of King City and Oak Ridges. The urban land use occurring within subbasin E-8 is associated with the town of Woodbridge.

As indicated in Figure 3.15, agricultural land use within the West Humber River basin is significant. It forms between 45 and 96% of the land use within each of the West Humber River subbasins. The proportion of pasture land within each subbasin appears inconsequential on Figure 3.15, relative to agricultural land use, but it is important because of where it occurs. Grazing areas on the West Humber River typically border either one or both sides of the watercourse, and the field inventory, (Section 3.9), revealed many areas of extensive livestock access. The Urban and Forested components are minimal within most West Humber River subbasins.

3.8 **Overland Sediment Delivery**

Soil Loss Mapping indicated that the most significant overland delivery potential exists from subbasins in the central and northern portions of the Humber and East Humber River basins (Figures 3.16 and 3.17 (in map pocket)).

Overall, the H-10(T) subbasin (Cold Creek), has the potential to deliver the greatest amount of overland sediment, with 1,210 ha of targeted farmland (Appendix 5). Subbasins H-75 and H-11, situated above and below Bolton respectively, and the two upstream tributary subbasins H-4(T) ("Coffey Creek")

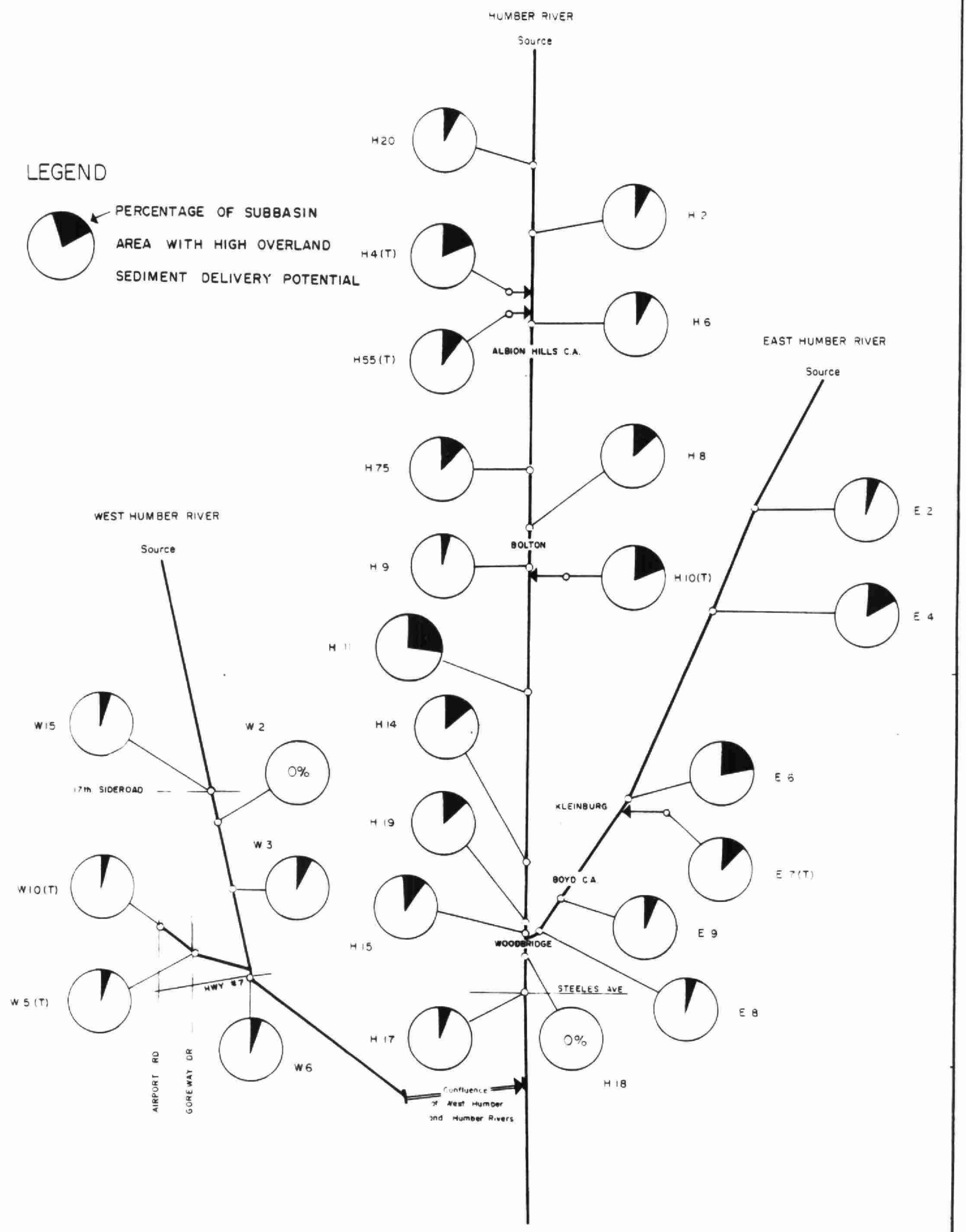

FIGURE 3.16

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UPPER HUMBER RIVER STUDY

FIGURE 3.16

OVERLAND SEDIMENT DELIVERY BY SUBBASIN

MARCH 1985

2 1 0 1 2 km

and H-55(T) (Centreville Creek) all exhibit between 400 and 500 ha of targeted land.

On the East Humber River, the most significant subbasin is E-6 with a targeted area of 1,021 ha. The subbasins E-2, E-4 and the tributary subbasin, E-7(T) have 399, 554, and 430 ha of targeted land respectively.

The West Humber River basin exhibits considerably less overland sediment delivery potential than either of the Humber or East Humber River watersheds. The greatest potential exists in subbasins W-15, W-5(T) and W-6.

The most critical factors in determining areas of High overland sediment delivery are the topography and land use of a region. The comparatively significant areas of High delivery potential in the northern subbasins are due in large part to the undulating topography of the Oak Ridges Moraine which extends through the upper portions of the study area. In the northern-most subbasins of the Humber River, the hummocky terrain would likely cause High sediment delivery to occur in spite of the predominant pasture land which is typically not a significant source of overland sediment. Not surprisingly, the more centralized subbasins are of greatest significance, where a combination of slightly rolling topography and row crop farming (e.g. corn system) potentially results in periodically severe inputs of overland sediment. As previously mentioned, the West Humber River exhibits comparatively little overland sediment delivery potential. Although the watershed is primarily agricultural, the generally level topography likely limits significant overland sediment inputs to those areas immediately adjacent to watercourses.

Considered in their entirety, the Humber River basin exhibits the greatest amount of targeted land with 4,203 ha targeted, followed by the East Humber River with 2,500 ha and the West

Humber River with 863 ha (Appendix 5). If considered on a per unit area basis (ha of High overland sediment delivery potential/km²), the Humber and East Humber River basins are quite similar exhibiting 12 and 13 ha/km² respectively. The West Humber watershed displays about 6 ha/km².

Complete overland sediment data are presented in Appendix 4.

3.9 **Field Inventory**

Stream Bank Erosion

The total area of exposed erosive stream bank was calculated for each subbasin. These total erosive areas were then divided by the length of inventoried stream bank within the corresponding subbasin so that an estimate of the erosive area per unit length of stream bank (m²/km) was obtained (Figure 3.18).

On the Humber River, subbasins H-19, H-14 and H-11 had the greatest per unit length stream bank erosion with values of 1,362, 961, and 624 m²/km respectively. The increased TSS loadings observed within these subbasins in dry weather may be at least partially attributable to stream bank erosion. All other Humber River subbasins had erosive areas of less than 400 m²/km, the lowest, 24 m²/km, was in the uppermost subbasin, H-20. Erosive area was consistently high on the East Humber River, the highest (792 m²/km) and lowest (384 m²/km) values occurring within subbasins E-6 and E-2 respectively. Most of the West Humber subbasins had high erosion, although subbasin W-10(T) was low at 100 m²/km.

Comparing the three rivers in their entirety, the West Humber River had the greatest erosive area per unit length at 1,486 m²/km, followed by the East Humber at 1,281 m²/km and the Humber at 949 m²/km.

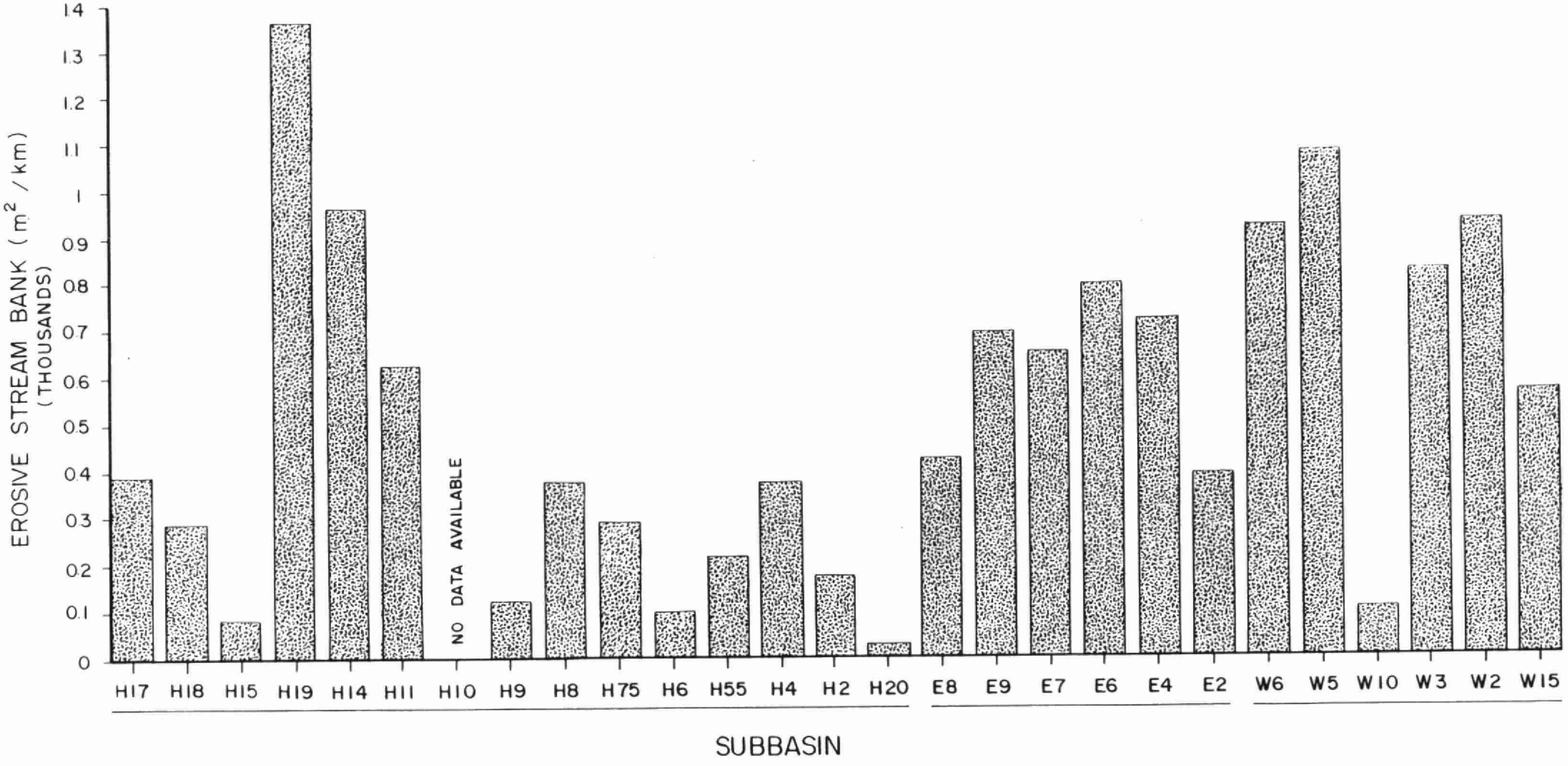

FIGURE 3.18

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UPPER HUMBER RIVER STUDY

STREAM BANK EROSIVE AREA

FIGURE: 3.18

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It should be emphasized that, while providing a comparative estimate of the degree of stream bank erosion within subbasins, the results discussed above may not always indicate which subbasins would contribute the greatest stream bank sediment load to the watercourse because they do not consider the relative size of the subbasins. For example, although the West Humber River has a greater amount of exposed erosive area per unit length than the Humber or East Humber Rivers, the West Humber is shorter and its total erosive area is less than the other two rivers. A summary of erosive area of stream bank by subbasin is included in Appendix 5.

Point Sources

Point source inflows identified during the field inventory are summarized by subbasin in Figure 3.19. Inflows were characterized as to whether they were natural (e.g. tributaries or springs) or anthropogenic (e.g. storm sewers, drainpipes, drainage ditches) and whether they were dry or flowing at the time of the inventory.

Natural inflows predominated in the upper reaches of the Humber River (i.e. from subbasin H-75 upstream), although anthropogenic inflows did occur, many of which were flowing. These anthropogenic inflows were primarily from pastoral, residential or small commercial land uses. The headwaters of Centreville Creek (H-55(T)) are in the community of Caledon East where some storm sewer outfalls exist.

Urban inputs were prevalent in subbasins H-9 and H-18 which corresponded to the towns of Bolton and Woodbridge respectively. These inputs were mainly storm sewers, some of which remained flowing in dry weather. Outfalls from sewage treatment plants (STPs) serving Bolton and Kleinburg were located in subbasins H-9 and H-19 respectively. Waste loadings from these STPs were previously reviewed by the MOE (MOE 1976b). After 1985, the Bolton STP will be taken out of

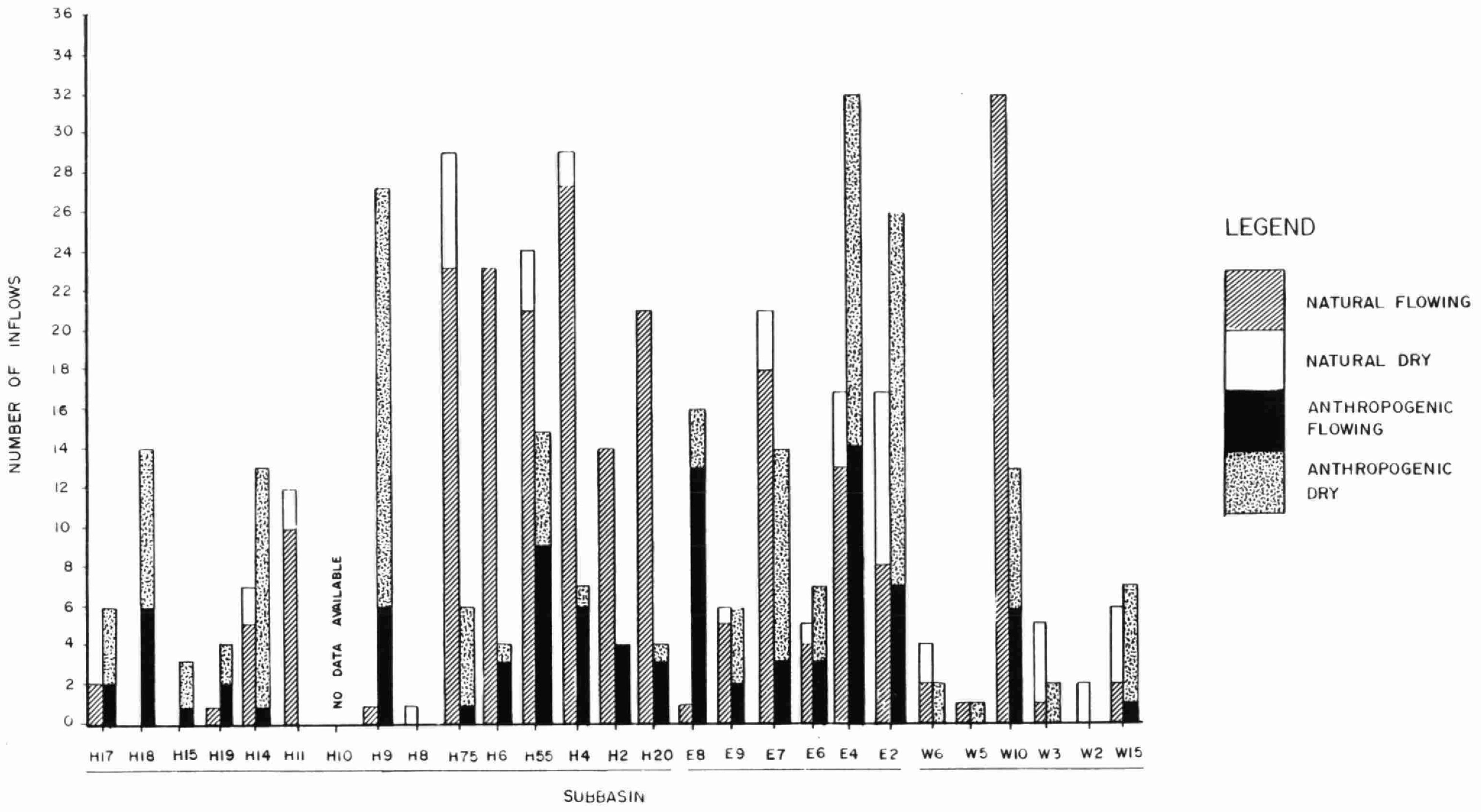

FIGURE 3.19

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UPPER HUMBER RIVER STUDY

POINT SOURCE INFLOWS

FIGURE: 3.19

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operation and sanitary sewage from Bolton will be directed south to Brampton via a trunk system (M. Schirller, personal communication).

Anthropogenic inputs in subbasin E-8 corresponded to that area of Woodbridge located within the East Humber River drainage. A large number of anthropogenic inflows were also found on the East Humber River in subbasins E-2 and E-4. Subbasin E-2 included the communities of King City and Oak Ridges. Subbasin E-4 had a mixture of agricultural and commercial land, with most development concentrated along the Highway 400 corridor.

Most of the inputs to the West Humber system were found on the tributary subbasin, W-10(T). One section of this tributary in particular had a heavy concentration of spring sources.

Anthropogenic inflows in the West Humber system were mostly agricultural in nature.

Locations of all identified point sources are shown in Figure 3.20 (in map pocket). Water samples were collected in dry weather from certain inflows which field staff considered likely sources of pollution. Those inflows that were sampled are marked with identification codes in Figure 3.20. Results of the water quality analysis are given in Appendix 5. Water quality data indicate that dry weather contaminant contributions from point sources may be significant.

Livestock Access

For each subbasin, the percentage of watercourse length which was subject to livestock access is indicated in Figure 3.21. The actual watercourse lengths experiencing livestock access are given in Appendix 5.

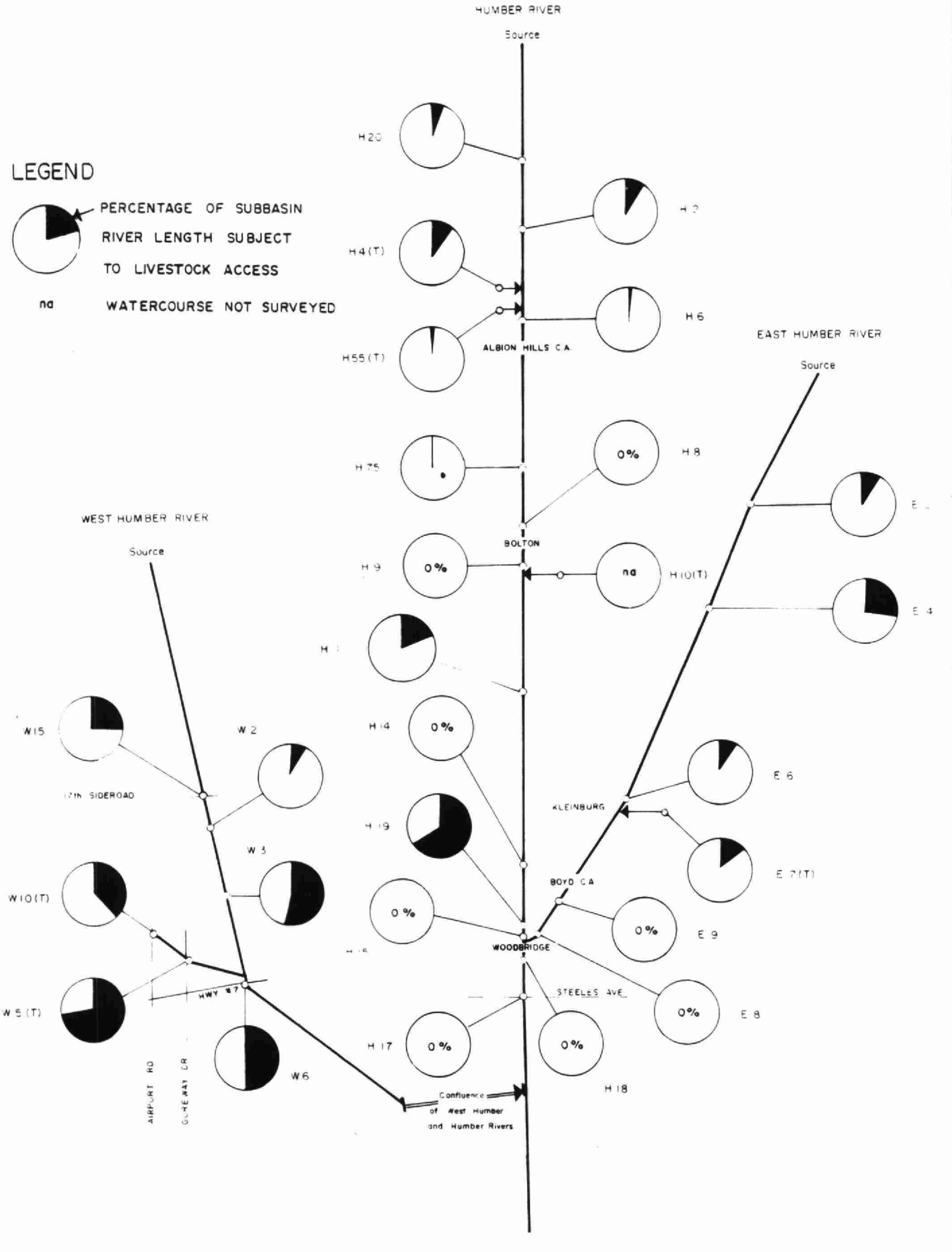

FIGURE 3.21

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UPPER HUMBER RIVER STUDY

PERCENTAGE LIVESTOCK ACCESS BY SUBBASIN

FIGURE 3.21

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2 1 0 1 2 km

Approximately 8 to 10% of subbasins H-20, H-2 and H-4(T) had livestock accessing the watercourse. Pasture land is predominant in these subbasins (Figure 3.15). Pasture land is likewise the dominant land use type in subbasins H-55(T) and H-6, however, watercourses in these subbasins did not have any extensive livestock access problems. On the Humber River, the greatest amounts of livestock access were found in the more southerly subbasins H-19 and H-11 where, respectively, 66% (3.9 km) and 19% (2.0 km) of the river was subject to livestock access. Livestock access may be a contributing factor to the pronounced stream bank erosion problems in these subbasins. Also, TSS and TP loadings generally increased within these subbasins. Similar bank erosion problems and loading increases in the adjacent subbasin H-14 cannot be attributed to livestock access, however, as none was found.

On the East Humber River, livestock access was noted only in subbasins upstream of Kleinburg. Access was most prevalent in subbasin E-4 where 27% (2.8 km) of the river was affected.

As noted in the Land Use section (section 3.7), livestock pasturing in the West Humber watershed is significant because of its concentration along the watercourses. Field investigations showed that all subbasins were influenced by livestock: percentage access varied from 7% in subbasin W-2 to 73% in subbasin W-5(T). The extremely high FC counts detected throughout the West Humber watershed in wet weather may be partially attributable to runoff from livestock operations located in close proximity to the watercourses.

The generally low FC levels throughout the Upper Humber watershed in Dry Event 3 may relate in part to seasonal variation in pasturing and other farming practices. In contrast to field observations made in the summer and early fall, livestock would not be pastured in December.

4. DISCUSSION

4.0 Discussion

Microbiological sampling indicated widespread water quality degradation throughout the Upper Humber watershed. With the exception of Dry Event 3 when levels were somewhat reduced, FC counts regularly exceeded the PWQO at most sampling stations. Exceedances were most pronounced during wet weather. Generally, wet weather FC exceedances on the West Humber and East Humber Rivers were greater than those on the Humber River.

Fecal pollution in the Upper Humber watershed originates from a combination of rural and urban sources. Even in the relatively undeveloped upper reaches of the watershed FC exceedances were commonplace. For example, at station H-20, located north of Highway 9 less than 10 km from the source of the Humber River, the geometric mean FC density was 112 counts per 100 ml in dry weather, with a maximum FC count of 540 recorded in midsummer. At H-2, the closest station downstream, the dry weather geometric mean FC density was 1,106 counts per 100 ml. Field investigations indicated that the high FC levels at H-20 were likely the result of a problem in the immediate vicinity of the sampling station. This points out that, although an area may be largely undeveloped, significant local problems may still exist.

The towns of Bolton and Woodbridge provide good examples of the effects of local urbanization in the watershed. Within both communities there were numerous point sources, some of which were shown to be potentially significant dry weather sources of fecal pollution. Fecal coliform counts regularly increased through the towns.

During the Synoptic Survey and Dry Event sampling the frequency and degree of TSS and TP exceedances were greatest in the Humber River subbasins between Bolton and Woodbridge. As well, these same subbasins (i.e. H-11, H-14, H-15) contributed the greatest dry weather loadings of TSS. These subbasins likewise had significant loadings of TP, however, large increases in TP loading also occurred upstream within the town of Bolton (i.e. subbasin H-9). Total suspended solids and TP increases between Bolton and Woodbridge may relate in part to the observed stream bank erosion and livestock access problems in this area. Wet weather TSS and TP exceedances were more widespread. Mean exceedance ratios were higher in wet than in dry weather.

In contrast to trends noted for TSS and TP, few significant spatial or weather-related differences in Cu or Pb concentrations were observed. These results corroborate other studies which indicate that significant inputs of Cu and Pb to watercourses can occur from diffuse atmospheric sources (precipitation and dry fallout) (Demayo et al. 1980, Demayo and Taylor 1981). One possible exception to this was subbasin E-8 which may be a source of Cu and Pb. The bed sediment sample from station E-8 had comparatively high concentrations of Cu and Pb as well as the highest observed Zn concentration.

Cadmium concentrations differed from those of Cu and Pb in that they were slightly less uniform throughout the study area and they increased dramatically under wet conditions. This suggests that Cd inputs to watercourses occur primarily from localized overland sources and are facilitated by storm event runoff.

The topography of the southwestern portion of the study area differs noticeably from the remainder of the Upper Humber watershed. The typically low relief and impervious nature of the Peel clays which predominate in the West Humber River basin inhibit rainwater retention, and during intense or prolonged storm events the watershed is extremely "flashy". In contrast to the Humber and East Humber River basins which have substantial base-flow contributions throughout the summer months, the summer base-flow component of the West Humber River is generally minimal. During summer months, as the soil loses its moisture, many watercourses in the watershed become intermittent and rely on periodic storm events to initiate flow. The only appreciable ground water contribution in summer occurred within the W-10(T) subbasin ("Gore Creek"), where several flowing springs were noted during field investigations. As a result of these consistent ground water inputs, "Gore Creek" is exceptional in that it maintains a measurable discharge during dry weather.

The significance of the West Humber's unique drainage basin topography was apparent during event sampling. In summer dry weather, the West Humber River had greatly reduced or intermittent flow; "Gore Creek" contributed a significant portion of the system's discharge. Even following the short-lived, intense rainfall in the wet portion of Dry Event 2 discharge in the West Humber River remained rather low. However, in response to the prolonged rainfall of the Wet Event, flow in the West Humber River became torrential, with peak discharge rivalling that of the Humber River at Woodbridge. During the Wet Event, subbasin W-6 became the major discharge and contaminant contributor.

As with subbasin W-6, the H-17 subbasin took on greater importance in the Wet Event. During the Wet Event, discharge and chemical loadings of the Humber River increased approximately 30% through subbasin H-17. This subbasin exhibited no loading increases of this magnitude in any of the other events, including the wet portion of Dry Event 2. The reason for subbasin H-17's increased importance in the Wet Event may stem from a combination of factors related to topography and land use. A major portion of subbasin H-17 is drained by "Rainbow Creek", a tributary which is confluent with the Humber River just above Steeles Avenue. Unlike other Humber River subbasins, the "Rainbow Creek" drainage basin is topographically similar to the West Humber River in that it is fairly level and it is dominated by Peel clays. This, combined with the predominantly urban land use in the extreme southern portion of the subbasin, would result in significant runoff during major storm events. Urban development already underway in other portions of this subbasin will in future further accentuate its importance in wet weather.

Other subbasins are likewise influenced by urbanization. For example, in subbasin E-8, near the mouth of the East Humber River, quicker storm water runoff resulted in rapid rises in river levels during the Wet Event.

The great disparity between dry and wet weather outputs of the West Humber drainage basin becomes significant when attempting to assess the relative impacts of the West Humber, Humber and East Humber Rivers on the lower Humber. Although the effects of Claireville Reservoir are not fully known, it is apparent that the relative impact of the West Humber River on the Lower Humber would be greater under wet as opposed to dry conditions.

The decreased chemical and microbiological concentrations in Dry Event 3 may indicate that the importance of contaminant sources varies with season. The late fall and winter months are characterized by reduced or absent livestock pasturing, crop tillage and construction, frozen soils and stream banks less susceptible to wind and water erosion, and precipitation which, instead of running off, is stored on the land as snow until spring. All of these would combine to reduce contaminant inputs to watercourses during this season.

Seasonal factors must also be considered in evaluating the Soil Loss Mapping. This mapping is designed to provide an indication of the relative potential of overland sources to deliver sediment to watercourses on an annual basis. The results of the mapping for the Upper Humber study area were not substantiated by wet weather sampling, however, this discrepancy is not surprising for several reasons. Of most significance is the fact that, on an annual basis, some 80 to 90% of overland sediment inputs typically occur during a critical 4 to 6 week period in the spring (D. Coleman, G. Wall, personal communication). By failing to adequately sample this period of the year, the relative importance of targeted lands (i.e. areas with a High overland delivery potential) appears to be considerably reduced.

The bed sediment samples collected were dominated by very fine sand. Although concentrations of TP were correlated with this grain size fraction, concentrations of trace metals were not. Trace metal concentrations were correlated with the finer, silt fraction which was, however, poorly represented in the bed sediment samples. Because of the trace metals' strong affinity for this sediment fraction it is important to better sample these finer sediments to more accurately evaluate the trace metal contributions of the subbasins.

5. CONCLUSIONS AND RECOMMENDATIONS

5.0 Conclusions and Recommendations

Conclusions

1. Exceedances of PWQO (or other environmental standards) for FC, TSS, TP, Cu, Pb and Cd occurred under wet and dry conditions throughout the Upper Humber watershed. The magnitude and frequency of exceedance varied with season, with wet versus dry conditions, with characteristics of the storm events and with seasonal changes in land use activities. Sampling results under dry conditions in December (Dry Event 3) indicated lowest pollutant concentrations and loadings. No PWQO exceedances of Zn occurred in the synoptic survey, but Zn bed sediment levels on the East Humber at Woodbridge (E-8) and downstream of King City - Oak Ridges (E-2) exceeded Open Lake Disposal Guidelines (OLDG). No other OLDG exceedances were detected in bed sediment.

2. Fecal Coliform and TP concentrations showed similar trends throughout the watershed. Although the frequency of exceedance was high under both dry and wet conditions, the magnitude of exceedance was much greater in wet weather. Exceedances were particularly frequent in the lower parts of the watercourses, particularly in the Bolton-Woodbridge area. Sampling of point source inputs in this area suggests that urban sources may be partially responsible for these elevated FC and TP concentrations. However, livestock access was extensive between Bolton and Woodbridge and this could also be contributing to higher parameter levels.

   Extensive areas of livestock access occurred throughout the West Humber and on the East Humber east of Nobleton. A number of subbasins in the East Humber watershed also exhibited high overland sediment delivery potential. The combined effect of livestock access and overland sediment delivery from these areas may help to explain the FC and TP exceedances in the lower parts of these watercourses.

3. Total suspended solids concentrations in excess of 25 mg/l were rare in dry weather and generally occurred in downstream subbasins. Dry weather loading trends were similar in that they were greatest in the lower subbasins (i.e. south of Bolton H-11, H-14, H-15). Urban development and livestock access problems may be aggravating stream bank and channel erosion throughout these subbasins.

   During the West Event, the main Humber and its tributaries north of Albion Hills made a relatively greater contribution to TSS loading at Steeles Avenue than during dry events. Tributary subbasins there (H-4(T), H-55(T)) had some of the largest areas of high overland sediment delivery potential. Large increases in Wet Event loadings also occurred through Bolton (H-9) and south of Woodbridge (H-17).

4. Copper concentrations usually exceeded PWQO throughout the watershed except during Dry Event 3. The frequency and magnitude of exceedances were similar in dry and wet conditions suggesting that Cu concentrations in surface waters during summer baseflow situations may be comparable to concentrations in storm event runoff from land surfaces. Diffuse atmospheric inputs are the most probable source.

5. Lead concentrations rarely exceeded PWQO during Dry Events 1 and 3, but during wet weather conditions, Pb concentrations increased slightly and exceedances were more common. However, in Dry Event 2 under low flow conditions widespread Pb exceedances occurred suggesting that the capacity of the watershed to dilute dry weather inputs was reduced. Diffuse atmospheric inputs are the most probable source.

6. Cadmium exceedances occurred at over three-quarters of the sampling stations during Dry Event 3. No exceedances occurred during Dry Event 3. During wet weather, however, both the magnitude and frequency of exceedance increased dramatically at most stations. Cd inputs to watercourses occur primarily from localized overland sources and are facilitated by storm event runoff.

7. Weather-related changes in subbasin flow contributions were significant. The West Humber River was intermittent along most of its length in summer dry conditions, yet discharge at Steeles Avenue during the Wet Event rivalled that of the main Humber at Steeles Avenue. This response may be partially explained by topography and soil type. The drainage basin of the West Humber is relatively flat and surface soils are clayey and poorly drained, typical of the Peel Plain. During storm events, the combination of poor soil permeability and low relief result in rapid overland transport of much of the precipitation directly to the watercourse; there is little opportunity for groundwater recharge. These runoff characteristics result in high stream discharges during storm events. Discharges in dry weather remain low because the baseflow component due to groundwater is minimal. Because of these discharge characteristics, the pollutant contribution of the West Humber River downstream of Steeles is likely important only during substantial runoff events. Its influence on the main Humber is unknown because all discharges and pollutant loads are mediated by Claireville Reservoir.

   During dry weather, the Humber River discharge at Albion Hills (27% of the drainage basin) represented over 50% of the discharge at Steeles Avenue. The East Humber discharge, at its confluence with the main Humber, represented 30 to 40% of the Humber River discharge at Steeles.

During the Wet Event, discharge contributions changed dramatically. The main Humber between its confluence with the East Humber and Steeles Avenue (H-17) contributed 30% of the discharge at Steeles although it represents only 10.4% of the watershed area. Rainbow Creek, a tributary entering the Humber within this subbasin and urban areas of Woodbridge may be responsible for the increased discharge contribution. Discharge contributions from the Humber River north of Albion Hills and from the East Humber dropped to about 30% and 22% of total flow, respectively.

8. Tributaries were among the subbasins with the largest area of high overland sediment delivery potential (H-10 (T), H-4(T), H-55(T), E-7(T)). The Humber River near Bolton and the East Humber upstream of Kleinburg also had large areas of high overland sediment delivery potential. In total about 7500 ha of land were targeted comprising 12-13% of West Humber drainage area.

9. Stream bank erosion was most extensive along the West Humber, the main Humber between Bolton and Woodbridge (H-11, HO-14, H-15) and the East Humber between Nobleton and Kleinburg (E-6). Impacts from small urban centres and livestock access may be aggravating bank erosion problems in these areas. The West Humber River had the greatest erosion area per unit length followed by the East Humber, then the main Humber.

Recommendations

1. Water quality problems in the Upper Humber watershed, although not of the magnitude of those occurring in the lower Humber, cannot be discounted in the development of a water management strategy if PWQO are to be achieved. Note that the implementation of pollution control measures in the predominantly rural Upper Humber watershed and the achievement of at least local compliance with PWQO would be less costly than the initiation of control options for the lower Humber River.

2. It is recommended that the MTRCA coordinate an abatement program with MOE Central Region, the Ontario Ministry of Agriculture and Food, and municipalities beginning with point source inputs and those livestock access problems immediately upstream of the swimming areas in the Claireville and Boyd Conservation Areas. Water quality problems in the Upper Humber watershed also cause localized water quality degradation. Of particular significance is the loss of public swimming facilities at Claireville Reservoir (West Humber River) due to fecal contamination. Livestock access problems were extensive in the West Humber and in the upper reaches of the East Humber, and point sources were also identified in the East Humber north of Boyd. It is suspected that these problems contribute to the contamination of conservation area beaches and could be abated through remedial measures such as livestock fencing and further investigation and abatement of point source problems.

3. More thorough evaluation of the behaviour of non-conservative parameters (i.e. FC, TP) should be conducted in the Upper Humber watershed to determine the potential effects of these parameters on the lower Humber River. This would involve obtaining information on the survival of bacteria and time to travel in the watercourses.

4. In view of the close association between TSS and contaminants, the role of sediment in pollutant transport should be further investigated. Where trace metals are of interest, sampling suspended as oppose to bed sediment may prove more beneficial.

5. The present and potential impacts of Claireville Reservoir on downstream quality should be evaluated.

6. Seasonal trends in contaminants loadings of the Upper Humber watershed should be further investigated. There is a particular need for more information pertaining to spring runoff. Additionally, more detailed characterization of storm events is required, as relative subbasin contributions seemed to vary between storms.

7. The significance of identified point sources to instream water quality should be evaluated with corrective measures initiated as required.

8. The relative importance of stream bank erosion and livestock access to instream water quality needs to be further evaluated, especially in the area between Bolton and Woodbridge.

9. A study should be conducted to assess the impacts of ongoing and future land use changes within the Upper Humber watershed.

10. Pathways (e.g. dry atmospheric fallout, precipitation, ground water) by which Cu and Pb enter the Upper Humber system should be further investigated.

11. The MTRCA should continue to apply the Soil Loss Mapping technique to other agricultural lands in its jurisdiction and verify and evaluate the results provided by this methodology.

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LITERATURE CITED

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APPENDIX 1

FIELD INVENTORY METHODS

Field Inventory Methods

The purpose of the field inventory was two-fold: firstly, to identify potential sources of pollution in the Upper Humber watershed (both point and non-point sources) and, secondly, to inventory all stream bank erosion sites. Two-person crews walked watercourses from mouth to source. Each crew member was responsible for recording pertinent information for one of the two stream banks. Data were recorded on "Unit Forms" and topographic maps of the area. An example of a Unit Form is presented in Table A.1. An explanation of the Unit Form follows.

A. Identification

Watercourse Name referred to the topographic map name of the watercourse. If no topographic name existed, local names or assigned names were used.

The **Drainage** system inventoried was indicated by circling either **WH** (West Humber River), **H** (Humber River), or **EH** (East Humber River).

Units were designated on topographic maps prior to the commencement of field work. The watershed was disaggregated on the basis of major landmarks, primarily concession roads. Each section of a watercourse between landmarks was assigned an identification code and called a "Unit".

B. Problem Land Use

Problem land use sites were numbered consecutively within each unit when identified. Locations were marked on topographic maps with site numbers prefixed with a "U" to distinguish these problem land use sites from point source inflows (prefix "I") and erosion sites (prefix "E").

Livestock Access - Areas where livestock such as cattle, horses, pigs had access to the watercourse, or where fences were absent or ineffectual. If no animals were seen, livestock access could still be noticeable from grazed vegetation, hoof tracks, fecal droppings, or other signs.

Riparian Tillage - This referred to the ploughing of fields or planting of crops within 100 m of the stream edge (in the "riparian" zone) without an adequate (>10 m wide) buffer strip of vegetation.

Improper Tillage - Generally speaking, this referred to the lack of contour ploughing, that is, land which had been ploughed parallel to the slope of the land rather than perpendicular to it.

Construction Site - Self-explanatory.

Intensive Recreation - Parks, golf courses, riding trails, swimming areas, etc.

Grass Cutting - Areas where there were lawns adjacent to the watercourse (within 100 m) and an adequate buffer strip (>10 m wide) was lacking. Such areas were common in conservation areas and golf courses, but also occurred at private residences.

Feedlot - Livestock feedlots located within 100 m of the watercourse.

Manure Storage - Farm manure piles found within 100 m of the watercourse.

Impervious Surface - Areas with little or no capacity for retention of water. These included: residential areas, parking lots, and industrial/commercial areas such as plazas, industrial parks, etc.

Debris - Garbage dumping, abandoned automobiles, etc.

Degree of Problem - A subjective evaluation of the degree of the problem. This could refer to the areal extensiveness of the problem, for example, riparian tillage along a 500 m length of watercourse as opposed to a 50 m length, or to the intensiveness of the problem, for example, dumping of household garbage as opposed to construction site debris.

C. Point Source Inflows

All locations of inflowing water were identified on topographic maps and described on Unit Forms. These included inflow points which were dry at the time of the field inventory.

Site No. - Point source inflows were numbered consecutively from one within each unit, and, on the topographic maps, prefixed with an "I".

Discharge was described in terms of flow, width and depth. A subjective estimate of **Flow** was given as either **Dry**, **Trickle**, **Moderate** or **Fast**. **Width** referred to the width of water in the case of unregulated flowing inputs such as tributaries or drainage ditches and to width of the channel in the case of dry or regulated inputs. **Depth** was the depth of water at the middle of the inflow and was recorded for flowing sources only.

Temperature was measured by submersing a thermometer in the inflowing water for at least one minute.

Conductivity was measured using a conductivity bridge when available.

The **Colour** of the inflowing water was described as **Clear**, **Yellow-Brown**, **Blue-Green**, **Turbid**, or **Other**.

Source - An indication of the probable source of the inflow.

For example, "outflow from farm pond", "runoff from road", "factory", etc.

D. Erosion Sites

All stream erosion sites were documented, whether strictly stream bank erosion sites or sites in which the stream bank was coincident with valley wall erosion. Valley wall erosion which was not coincident, that is, where there was a floodplain separating the stream bank from the valley wall, was not included.

Site No. - Again, this referred to the erosion site number as indicated on the topographic map. Sites were numbered consecutively within each unit.

Length - Estimated total length of the erosion site.

Average Height - Estimated average height of the erosion site. If there were large, abrupt changes in height at an erosion site, for example, as occurs when a stream bank erosion site is continuous with a coincident erosion site, the sites were considered separately.

Average Slope - Estimated average slope of the erosion site. For our purposes, the slope was defined as the angle between the face of the eroding bank and the horizontal. Slopes greater than 90 degrees could occur in the case of undercut, overhanging banks.

Area - Calculated as:
Area = (length x average height)/sine(average slope)

Type - An indication of whether the erosion was **Coincident** or **Stream Bank** and whether coincident erosion was **Sheet** or **Gully**. The face of a coincident site undergoing sheet erosion is relatively smooth since water washes over it in a broad, thin "sheetflow". Conversely, a coincident site with gully (rill) erosion has deep troughs cut down its slope as a result of the surface runoff being largely concentrated into discrete channels.

Aspect - An indication of whether the erosion site occurred on a **Straight** stretch of river or on a **Bend** in the river. One erosion site could conceivably encompass both a straight stretch and a bend.

Active Time - An indication of when the watercourse would erode the site. If water was contacting the erosion site, **Normal Flow** was indicated. If the erosion site was not at all contacted by water, but it appeared that it would be contacted during higher flows, **High Flow** was chosen.

Dominant Soil Type(s) - The dominant type or types of soil comprising the erosion site were identified. **Loam** is a soil consisting of an easily-crumbled mixture of clay, silt, and sand. Loams cover a large area of the Humber watershed and were encountered at most erosion sites. **Sand/Gravel** refers to gritty material originating from crystalline rock. Sand particles are smaller than gravel, usually less than 0.2 cm in diameter. Gravel is composed of loose rounded fragments of rock between 0.2 and 8 cm in diameter. **Clay** is a smooth material of inorganic origin with a greasy feel between the fingers and no apparent structure. It hardens considerably when dry. **Rock** refers to all exposed rock with no overburden. Shale is one of the more common rock types comprising erosion sites in the Upper Humber watershed.

Vegetative Cover-Face - An estimate of the extent to which the face of the erosion site was vegetated.

Crest-Dominant Vegetation - The dominant type of bank vegetation along the crest (top) of the erosion site. This entailed the area within approximately 3 to 5 m of the face of the erosion site. Whether or not livestock grazed in this area was indicated.

Erosion Rate - A subjective estimation of the erosion rate at the site, either **Low**, **Medium**, or **High**. Signs of crest slumping were noted.

E. Unit Summary

In this section of the form crew members had the opportunity to expand upon observations they considered significant and to generally document their overall impression of the unit they had walked through. The unit summary was completed at the end of each unit. If more than one day was required to complete a unit, a unit summary was filled out each day for the portion inventoried that day.

Table A.1 Field Inventory Unit Form

the metropolitan toronto and region conservation authority

UPPER HUMBER WATERSHED SURVEY - UNIT FORM (form ____ of ____)

A. IDENTIFICATION

WATERCOURSE NAME ______________________ DRAINAGE WH H EH

UNIT ______________ BANK SIDE R Flow L

INVESTIGATOR ______________________ DATE ______________

(OFFICE USE ONLY)

B. PROBLEM LAND USE

	TYPE OF PROBLEM (indicate those applicable)											DEGREE OF PROBLEM			
SITE NO.	LIVESTOCK ACCESS	RIPARIAN TILLAGE	IMPROPER TILLAGE	CONSTRUCTION SITE	INTENSIVE RECREATION	GRASS CUTTING	FEEDLOT	MANURE STORAGE	IMPERVIOUS SURFACE	DEBRIS	OTHER	SLIGHT	MODERATE	SEVERE	COMMENTS

Table A.1 (Continued)

C. POINT SOURCE INFLOWS

	TYPE						DISCHARGE						CHEMISTRY		COLOUR					
							FLOW													
SITE NO.	DRAINPIPE	TILE OUTFALL	STORM SEWER	DRAINAGE DITCH	TRIBUTARY OR SPRING	OTHER	DRY	TRICKLE	MODERATE	FAST	WIDTH (m)	DEPTH (m)	TEMPERATURE (°C)	CONDUCTIVITY (umhos/cm2)	CLEAR	YELLOW-BROWN	BLUE-GREEN	TURBID	OTHER	SOURCE

D. EROSION SITES

	DIMENSIONS				TYPE			ASPECT		ACTIVE TIME		DOMINANT SOIL TYPE(S)				VEGETATIVE COVER-FACE				CREST-DOMINANT VEGETATION					EROSION RATE			
SITE NO.	LENGTH (m)	AVERAGE HEIGHT (m)	AVERAGE SLOPE (°)	AREA (m^2)	COINCIDENT SHEET	COINCIDENT GULLY	STREAM BANK	STRAIGHT	BEND	NORMAL FLOW	HIGH FLOW	LOAM	SAND/GRAVEL	CLAY	ROCK	0	$<\frac{1}{3}$	$\frac{1}{3}-\frac{2}{3}$	$>\frac{2}{3}$	NONE	GRASSES	SHRUBS	TREES	GRAZING	LOW	MEDIUM	HIGH	SLUMPING

Table A.1 (Continued)

E. UNIT SUMMARY

WATER TEMPERATURE ________ C

AIR TEMPERATURE ________ C

TIME __________

DATE __________

PRECIPITATION TODAY: Y N

PRECIPITATION YESTERDAY: Y N

GENERAL WATERCOURSE CHARACTERISTICS

AVERAGE WIDTH ____________ m

AVERAGE DEPTH ____________ m

STREAM MORPHOLOGY:

STREAMBED COMPOSITION:

GENERAL CONDITION OF STREAM BANKS (Slumping, etc.)

DOMINANT ADJACENT LAND USES

POLLUTION OCCURRENCE

MAJOR AREAS OF SEDIMENT DEPOSITION

TOTAL NUMBER OF UNIT FORMS USED IN THIS UNIT ________________

APPENDIX 2
WATER QUALITY DATA

Notes for Appendix 2

Abbreviation	Variable
Q	instantaneous discharge
TSS	total suspended solids
TDS	total dissolved solids
COND	conductivity
OP	orthophosphate
TP	total phosphorus
BOD	biochemical oxygen demand
Cu	copper
Pb	lead
Cd	cadmium
Zn	zinc
TKN	total kjeldahl nitrogen
AMM-N	ammonia nitrogen
NO_3^-	nitrate
NO_2^-	nitrite
FC	fecal coliforms
EC	*Escherichia coli*
FS (M-ENT)	fecal streptococcus (M-enterococcus)
FS (M-E)	fecal streptococcus (M-E)
FS (K-F)	fecal streptococcus (K-F)
PA	*Pseudomonas aeruginosa*
NA	no data available

SYNOPTIC SURVEY

SYNOPTIC SURVEY

Water Chemistry Data - June 20, 1984.

STATION	TSS (mg/l)	TDS (mg/l)	COND (umhos/cm^2)	AMM-N (mg/l)	TKN (mg/l)	NO_3-N (mg/l)
H-1	16/8	300/300	420	.04	.45	9.6
H-2	4	320	450	.05	.49	3.7/3.7
H-3	16	310	400	.06/.04	.29	2.1
H-4(T)	4	300	410	.02	.50	2.2
H-5(T)	16	250	400	.02	.24	.60
H-6	8	300	400	.03	.29/.22	1.47
H-7	24	260	460	.04/.04	.34	1.60
H-9	28	310	400	.03	.56	3.7
H-10(T)	12	290	450	.01/.01	.13	.60
H-11	48/52	280/270	450	.05	.41	2.5/2.3
H-14	124	260	420	<.01	.46/.39	2.2
H-15	64	300	430	.02	.46/.52	1.71
H-16(T)	12	600	750	.07/.04	.71	1.34
H-17	60	350/350	480	.01	.46/.43	1.90
E-1	28	370	560	.05/.04	.69	1.19
E-2	28	360	560	.06	.60	.85
E-3(T)	16	390	560	.03	.49	.72
E-4	20	350	520	.07	.55/39	.91
E-5(T)	16/28	430	680	.01/.01	.53	.41
E-6	32/28	290/290	480	.01	.33/.33	.80
E-7(T)	12	400	570	.02/.02	.21	1.27/1.22
E-8	48	200	550	.02	.26	.54
W-1	24	280	450	.01	.26/.33	.05
W-2	12	360	580	.02/.02	.38	.15
W-3	16/16	330/350	500	<.01	.36	.10
W-4(T)	56	370	550	.01/<.01	.45	.09
W-5(T)	96	270	480/470	.03	.58/.60	10.4
W-6	32	350	500/490	.03	.47	2.8
W-7(T)	12/24	550/540	770	.04	.60	.30
W-8(T)	12	460	700/700	<.01	.48	.08

SYNOPTIC SURVEY (Continued)

Water Chemistry Data - June 20, 1984.

STATION	NO_2-N (mg/l)	OP (mg/l)	TP (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)	Cd (mg/l)
H-1	.023	.011	.046/.052	.006	.025	.005	.001
H-2	.011/.011	.006	.036	.014	.025	.004	.003
H-3	.021	.004	.050	.006	.025	.004	.003
H-4(T)	.006	<.002	.032	.003	.025	.004	.002
H-5(T)	.007	.006	.038	.014	.025	.002	.001
H-6	.014	.004	.046	.004	.020	.008	.001
H-7	.014	.004	.056/.062	.003	.025	.005	.001
H-9	.015	.010	.088	.015	.020	.017	<.001
H-10(T)	.014	.004	.022/.026	.009	.030	.006	.002
H-11	.018	.004	.082	.019	.025	.007	.002
H-14	.020/.022	<.002	.132	.018	.025	.007	.001
H-15	.020	.010	.116/.112	.005	.015	.008	.001
H-16(T)	.035	.018	.044	.005	.025	.008	.002
H-17	.018/.018	.012	.064	.009	.025	.008	.004
E-1	.021	.034	.098	.013	.025	.005	.001
E-2	.004	.028	.076	.024	.025	.005	.001
E-3(T)	.018/.019	.016	.052/.052	.015	.020	.003	.001
E-4	.026	.012	.054	.002	.025	.005	.001
E-5(T)	.008	.008	.052	.017	.025	.004	.001
E-6	.014	<.002	.036	.010	.030	.002	.001
E-7(T)	.010	.004	.040	.015	.025	.007	.002
E-8	.007	<.002	.024	.016	.025	.011	.001
W-1	.002	.004	.050	.008	.025	.006	.003
W-2	.002/.003	<.002	.026	.013	.025	.003	.002
W-3	.004	.008	.036	.019	.030	.002	.001
W-4(T)	.004	.016	.038	.011	.025	.004	<.001
W-5(T)	.068	.016	.038	.018	.025	.004	.002
W-6	.031	.004	.044	.019	.020	.004	.001
W-7(T)	.008	.004	.032	.021	.025	.006	.001
W-8(T)	.003	.004	.028	.003	.025	.005	<.001

SYNOPTIC SURVEY

Microbiological Data - June 20-22, 1984.

Station	Fecal Coliforms			E. coli			Fecal Streptococcus			Pseudomonas aeruginosa		
	1	2	3	1	2	3	1	2	3	1	2	3
H-1	90	70	110	90	70	110	80	64	72	2	4	<2
H-2	2900	260	800	2900	260	800	240	144	610	2	<2	<2
H-3	110	130	90	110	130	90	84	40	72	4	<2	<2
H-4(T)	110	110	270	110	110	270	108	88	96	<2	<2	<2
H-5(T)	510	460	380	510	460	380	188	324	168	8	2	4
H-6	130	30	130	130	30	130	84	72	100	<2	4	<2
H-8	70	10	120	70	10	120	28	32	36	12	4	<2
H-9	400	110	80	370	110	80	216	192	204	21	8	4
H-10(T)	40	220	20	30	220	20	144	208	120	<2	<2	<2
H-12	320	120	140	320	120	140	64	80	100	32	15	2
H-13	150	170	170	150	170	170	36	76	152	15	2	<2
H-15	60	10	100	60	10	100	44	32	120	34	<2	4
H-16(T)	200	240	70	200	240	70	152	320	200	8	<2	<2
H-17	120	130	140	100	130	140	80	108	136	49	9	<2
E-1	300	280	180	300	280	180	332	252	256	2	<2	4
E-2	300	180	390	300	170	390	184	128	224	2	2	16
E-3(T)	120	240	260	120	240	260	404	470	550	<2	<2	2
E-4	230	180	670	230	180	670	88	92	120	<2	<2	3
E-5(T)	180	440	340	180	420	390	244	730	790	<2	2	23
E-6	60	50	70	60	50	70	48	52	84	<2	<2	3
E-7(T)	160	140	120	160	140	120	104	120	124	2	<2	<2
E-8	3200	2780	360	3200	2780	360	132	1330	124	2	<2	2
W-1	30	<10	110	30	<10	110	32	40	36	5	<2	<2
W-2	2500	280	500	2500	280	500	640	184	980	<2	<2	<2
W-3	430	130	620	430	130	620	192	88	330	<2	<2	<2
W-4(T)	60	<10	60	60	<10	60	144	140	116	4	<2	<2
W-5(T)	320	1300	510	320	1300	510	176	144	204	15	7	6
W-6	230	<10	<10	230	<10	<10	72	84	340	37	13	4
W-7(T)	60	<10	70	60	<10	70	428	260	112	<2	<2	2
W-8(T)	100	<10	<10	100	<10	<10	140	180	180	<2	<2	2

DRY EVENT 1

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - DRY EVENT 1 (July 23-25,1984)

STATION	DAY	Q (cms)	TSS (mg/l)	TDS (mg/l)	COND (umhos /cm2)	OP (mg/l)	TP (mg/l)	BOD (mg/l)	Cu (mg/l)	Pb (mg/l)	Cd (mg/l)
H-17	1	1.47	28	305	450	0.02	0.06	0.1	0.0062	0.02	NA
	2	1.42	32	320	450	0.02	0.06	0.1	0.016	0.02	NA
	3	1.35	16	300	450	0.02	0.06	0.9	0.01	0.016	NA
H-15	1	1.13	51	280	420	0.04	0.05	0.1	0.008	0.02	NA
	2	1.08	41	260	420	0.02	0.08	0.1	0.011	0.018	NA
	3	0.992	28	320	430	0.02	0.07	0.8	0.017	0.016	NA
H-14	1	1.18	22	280	400	0.03	0.06	0.6	0.02	0.019	NA
	2	1.12	31	230	400	0.02	0.07	0.6	0.01	0.02	NA
	3	1.07	19	270	400	0.02	0.04	0.8	0.026	0.016	NA
H-11	1	1.19	32	300	440	0.01	0.06	0.1	0.014	0.019	NA
	2	1.12	27	290	440	0.02	0.06	0.3	0.011	0.02	NA
	3	1.07	23	285	440	0.01	0.04	0.7	0.01	0.016	NA
H-10(T)	1	0.244	9	280	460	0.01	0.07	0.2	0.011	0.019	NA
	2	0.239	10	295	450	0.02	0.06	0.3	0.014	0.018	NA
	3	0.239	5	315	460	0.01	0.05	0.5	0.013	0.014	NA
H-9	1	0.944	30	312	450	0.03	0.05	0.2	0.014	0.018	NA
	2	0.892	30	315	450	0.02	0.09	1	0.016	0.016	NA
	3	0.816	14	325	450	0.02	0.06	2.4	0.014	0.014	NA
H-75	1	0.834	9	320	450	0.02	0.06	0.1	0.028	0.02	NA
	2	0.78	14	325	450	0.02	0.04	0.1	0.01	0.018	NA
	3	0.707	6	280	450	0.02	0.03	0.1	0.014	0.014	NA
H-6	1	0.904	5	305	450	0.01	0.05	0.3	0.03	0.019	NA
	2	0.855	6	300	420	0.01	0.06	1.9	0.027	0.018	NA
	3	0.796	4	300	450	0.01	0.04	2.4	0.017	0.014	NA
H-55(T)	1	0.168	8	280	400	0.01	0.04	0.3	0.022	0.017	NA
	2	0.167	8	280	400	0.01	0.07	0.3	0.0085	0.016	NA
	3	0.159	7	280	400	0.01	0.04	2.1	0.01	0.014	NA
H-4(T)	1	0.176	5	310	450	0.01	0.05	0.6	0.02	0.018	NA
	2	0.163	8	270	450	0.01	0.04	0.7	0.006	0.018	NA
	3	0.148	2	310	450	0.01	0.03	1.7	0.015	0.014	NA
E-8	1	0.588	5	370	580	0.01	0.04	0.3	0.018	0.024	NA
	2	0.556	6	380	580	0.01	0.06	0.3	0.024	0.02	NA
	3	0.54	5	395	580	0.01	0.04	1.7	0.0075	0.016	NA
E-7(T)	1	0.081	36	380	580	0.04	0.06	0.1	0.01	0.023	NA
	2	0.079	38	375	580	0.01	0.06	0.1	0.01	0.022	NA
	3	0.072	24	380	580	0.01	0.06	1.2	0.014	0.02	NA
E-6	1	0.148	20	295	520	0.01	0.08	0.1	0.0062	0.02	NA
	2	0.155	22	325	520	0.01	0.09	0.1	0.006	0.018	NA
	3	0.133	16	340	520	0.01	0.04	1.4	0.0065	0.016	NA
E-4	1	0.4	24	345	580	0.04	0.07	1.7	0.014	0.022	NA
	2	0.105	11	400	580	0.01	0.07	1.7	0.007	0.02	NA
	3	0.034	12	390	570	0.01	0.05	1.6	0.0065	0.016	NA
E-2	1	NA	14	378	650	0.06	0.1	1.5	0.011	0.026	NA
	2	NA	14	410	640	0.06	0.09	1.5	0.021	0.024	NA
	3	NA	8	420	650	0.02	0.07	1.3	0.0045	0.018	NA
W-6	1	0.09	22	310	450	0.04	0.07	0.1	0.024	0.02	NA
	2	0.09	26	320	450	0.04	0.07	0.1	0.021	0.02	NA
	3	0.085	36	270	450	0.06	0.06	0.7	0.015	0.016	NA

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - DRY EVENT 1 (July 23-25,1984)

STATION	DAY	Q (cms)	TSS (mg/l)	TDS (mg/l)	COND (umhos /cm2)	OP (mg/l)	TP (mg/l)	BOD (mg/l)	Cu (mg/l)	Pb (mg/l)	Cd (mg/l)
W-5(T)	1	0.022	6	310	470	0.02	0.13	0.3	0.021	0.019	NA
	2	0.022	6	320	470	0.02	0.05	0.3	0.0095	0.018	NA
	3	0.015	4	295	470	0.02	0.04	0.8	0.013	0.016	NA
W-10(T)	1	0.031	4	315	450	0.02	0.07	0.1	0.02	0.018	NA
	2	0.027	4	355	450	0.03	0.07	0.1	0.01	0.018	NA
	3	0.025	5	330	450	0.02	0.06	0.7	0.014	0.018	NA
W-15	1	0.004	2	280	400	0.01	0.02	0.1	0.026	0.016	NA
	2	0.004	4	280	400	0.02	0.02	0.1	0.012	0.014	NA
	3	0.003	2	282	400	0.01	0.02	1.4	0.018	0.016	NA

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 1 (July 23-27,1984)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-17	1	92	92	72	20	124	<4	13
	2	156	148	72	4	84	<4	8
	3	44	44	52	4	100	8	19
	4	196	192	140	20	228	20	83
	5	240	224	148	24	204	20	27
H-18	1	180	180	124	4	44	10	3
	2	360	360	56	4	96	16	5
	3	80	80	56	4	76	12	14
	4	144	144	148	36	240	16	37
	5	310	300	196	20	144	8	19
H-19	1	208	208	48	4	112	<4	14
	2	396	384	28	10	136	4	12
	3	56	56	8	16	116	10	4
	4	220	220	76	30	450	20	25
	5	152	148	140	16	340	<4	38
H-11	1	180	176	60	16	88	<4	9
	2	96	96	72	24	168	10	8
	3	136	136	72	12	340	8	6
	4	580	580	152	60	176	8	15
	5	460	450	152	28	136	30	12
H-10(T)	1	136	132	236	68	120	8	2
	2	452	436	320	128	172	32	4
	3	104	104	420	100	900	10	14
	4	104	100	420	120	620	36	10
	5	260	188	420	144	370	40	14
H-9	1	232	208	160	60	152	12	9
	2	320	220	188	60	128	20	11
	3	152	152	104	12	108	8	2
	4	400	390	224	28	204	20	4
	5	700	670	348	104	280	32	6
H-8	1	76	76	58	12	160	16	3
	2	68	68	70	10	184	10	4
	3	32	32	16	6	224	4	4
	4	184	184	100	10	870	8	5
	5	176	164	184	44	350	20	19
H-6	1	152	152	224	40	64	4	3
	2	200	200	188	36	132	10	2
	3	80	80	144	20	550	12	8
	4	64	64	192	60	510	16	2
	5	208	200	260	84	580	24	8
H-55(T)	1	70	70	24	4	650	<4	2
	2	40	40	20	8	340	<4	0
	3	20	20	12	12	950	4	1
	4	20	20	28	4	870	<4	2
	5	<10	<10	24	8	720	<4	0

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 1 (July 23-27,1984)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-2	1	1140	1050	830	320	540	<4	1
	2	5000	4600	760	140	580	10	3
	3	300	260	140	12	160	8	0
	4	1200	1200	710	400	750	12	2
	5	1930	1770	1110	300	610	140	5
H-20	1	540	540	410	132	164	8	0
	2	230	230	390	40	232	12	2
	3	150	150	400	32	710	<4	4
	4	210	210	670	300	790	25	2
	5	310	300	740	380	790	<4	3
E-8	1	670	650	590	240	196	160	8
	2	260	260	216	1090	260	24	6
	3	160	130	128	60	160	40	6
	4	190	190	160	120	204	20	4
	5	1160	1140	384	144	490	<4	5
E-9	1	130	120	24	<4	92	<4	8
	2	20	20	60	16	68	<4	3
	3	10	<10	24	<4	84	<4	2
	4	80	80	52	50	96	<4	7
	5	3300	3200	196	100	148	24	1
E-6	1	84	84	88	20	80	48	3
	2	184	184	156	52	108	32	24
	3	36	36	96	20	104	20	2
	4	36	36	240	56	176	32	3
	5	100	100	176	48	136	8	5
E-4	1	740	610	610	120	188	32	159
	2	230	230	196	60	224	28	4
	3	200	180	152	12	250	25	6
	4	260	260	670	272	690	130	334
	5	320	310	580	108	384	140	75
E-2	1	460	460	228	56	128	32	13
	2	330	320	332	72	156	28	13
	3	100	100	216	48	800	12	4
	4	90	90	440	120	470	24	9
	5	160	150	324	84	540	20	8
W-6	1	80	80	92	10	64	16	2
	2	48	40	44	<4	40	<4	3
	3	8	8	28	<4	116	4	2
	4	200	160	100	4	76	12	22
	5	276	276	168	52	132	32	41
W-5(T)	1	190	190	132	4	112	40	3
	2	130	130	108	4	156	24	1
	3	70	70	72	4	252	32	3
	4	130	130	290	32	540	28	9
	5	150	130	228	52	288	16	20

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 1 (July 23-27,1984)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
W-10(T)	1	250	250	600	68	188	40	4
	2	270	270	520	52	410	<4	2
	3	200	200	264	64	192	8	5
	4	410	370	650	104	360	60	2
	5	570	570	710	116	490	4	9
W-3	1	220	220	270	120	120	8	<2
	2	1000	1000	330	172	230	<4	2
	3	100	90	148	76	220	4	3
	4	280	280	376	76	112	20	0
	5	2700	2700	390	184	300	20	1
W-2	1	4100	4100	1860	350	1550	<4	8
	2	6700	6700	2800	560	860	<4	24
	3	4400	4300	1700	490	1370	<4	5
	4	2450	2410	1670	420	880	<4	8
	5	3000	3000	2030	510	1890	NA	120

DRY EVENT 2

UPPER HUMBER RIVER STUDY

CHEMICAL DATA - DRY EVENT 2 (August 27-29 & September 4,1984)

(asterisks indicate wet weather days)

STATION	DAY	Q (cms)	TSS (mg/l)	TDS (mg/l)	COND (umhos /cm2)	OP (mg/l)	TP (mg/l)	BOD (mg/l)	Cu (mg/l)	Pb (mg/l)	Cd (mg/l)
H-17	1	1.24	30	275	440	0.004	0.059	10.5	0.0085	0.03	<0.0005
	2	1.2	27	295	440	0.006	0.05	1.4	0.007	0.018	<0.0005
	3 *	3.62	700	312	432	0.042	0.42	2.5	0.042	0.082	0.012
	4 *	3.62	170	298	465	0.024	0.23	0.8	0.008	0.058	<0.0005
H-15	1	0.992	44	265	435	0.006	0.099	1.2	0.011	0.022	0.001
	2	0.95	41	295	430	0.009	0.07	1.4	0.006	0.016	<0.0005
	3 *	4.16	820	290	400	0.052	0.158	3.1	0.038	0.085	0.009
	4 *	2.81	202	295	445	0.022	0.26	1.2	0.0075	0.056	<0.0005
H-14	1	1.03	30	260	425	0.009	0.088	1.3	0.0075	0.023	<0.0005
	2	0.984	44	85	420	0.013	0.028	1.7	0.014	0.024	0.0005
	3 *	3.77	640	250	390	0.04	0.65	2.8	0.034	0.076	0.01
	4 *	2.72	155	285	448	0.024	0.25	1.2	0.007	0.057	<0.0005
H-11	1	0.998	24	275	440	0.015	0.07	1.3	0.0055	0.028	0.0005
	2	0.971	24	320	445	0.013	0.05	1.2	0.008	0.018	0.0005
	3 *	2.2	770	395	270	0.074	0.94	4.6	0.049	0.119	0.016
	4 *	2.48	100	295	440	0.019	0.13	1	0.012	0.052	0.0005
H-10(T)	1	0.213	4	290	455	0.01	0.019	0.9	0.0075	0.038	0.001
	2	0.227	7	290	455	0.009	0.023	0.9	0.009	0.014	<0.0005
	3 *	0.504	80	270	385	0.024	0.114	1.3	0.013	0.034	0.0039
	4 *	0.283	14	290	450	0.019	0.042	0.4	0.0035	0.046	0.0005
H-9	1	0.854	18	280	460	0.031	0.071	1.3	0.036	0.036	<0.0005
	2	0.854	15	320	455	0.011	0.02	1.6	0.0075	0.016	<0.0005
	3 *	1.579	210	310	445	0.036	0.216	2.5	0.018	0.042	0.0055
	4 *	2.25	74	310	440	0.032	0.092	1	0.0076	0.04	0.0005
H-75	1	0.773	5	270	420	0.006	0.026	1	0.016	0.028	<0.0005
	2	0.773	6	285	418	0.007	0.035	1.2	0.004	0.02	<0.0005
	3 *	1.42	24	290	400	0.013	0.059	2	0.015	0.031	<0.004
	4 *	2	34	275	420	0.009	0.076	0.8	0.005	0.04	0.0005
H-6	1	0.69	5	260	430	0.009	0.03	2.2	0.021	0.044	0.001
	2	0.69	4	295	425	0.008	0.028	2	0.0055	0.018	<0.0005
	3 *	1.61	50	295	410	0.013	0.116	2.2	0.013	0.036	0.0038
	4 *	1.95	22	305	420	0.011	0.051	NA	0.0052	0.038	<0.0005
H-55(T)	1	0.172	8	260	400	0.006	0.029	1.7	0.01	0.046	0.0015
	2	0.168	7	285	390	0.007	0.04	1.4	0.017	0.022	0.001
	3 *	0.333	9	370	380	0.013	0.065	2.6	0.009	0.027	<0.004
	4 *	0.541	7	260	390	0.007	0.092	1.6	0.016	0.04	<0.0005
H-4(T)	1	0.132	6	300	450	0.01	0.024	1.2	0.0045	0.038	0.001
	2	0.129	9	302	440	0.01	0.035	1.2	0.013	0.032	0.0015
	3 *	0.5	146	270	400	0.014	0.217	3.4	0.013	0.038	0.0052
	4 *	0.27	24	278	435	0.019	0.047	0.4	0.0082	0.043	<0.0005
E-8	1	0.459	1	360	565	0.006	0.012	0.7	0.0085	0.052	<0.0005
	2	0.453	<1	350	560	0.004	0.031	1.2	0.003	0.052	0.001
	3 *	1.79	96	330	400	0.015	0.112	1.4	0.02	0.058	0.0025
	4 *	1.04	25	328	530	0.006	0.058	0.6	0.005	0.044	<0.0005
E-7(T)	1	0.074	8	325	535	0.007	0.01	0.7	0.016	0.044	0.001
	2	0.072	8	330	520	0.006	0.018	1	0.004	0.042	0.0005
	3 *	0.707	560	290	440	0.043	0.106	1.3	0.051	0.12	0.017
	4 *	0.103	58	400	600	0.011	0.078	0.2	0.013	0.046	0.0015

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - DRY EVENT 2 (August 27-29 & September 4,1984)
(asteriske indicate wet weather days)

STATION	DAY	Q (cms)	TSS (mg/l)	TDS (mg/l)	COND (umhos /cm2)	OP (mg/l)	TP (mg/l)	BOD (mg/l)	Cu (mg/l)	Pb (mg/l)	Cd (mg/l)
E-6	1	0.08	12	350	540	0.006	0.029	1	0.026	0.048	0.001
	2	0.083	15	330	520	0.007	0.031	1	0.004	0.042	0.001
	3 *	0.286	118	290	420	0.014	0.061	1.3	0.014	0.072	0.002
	4 *	0.371	37	325	600	0.009	0.043	0.4	0.007	0.04	0.0005
E-4	1	0.074	4	370	570	0.009	0.012	1.3	0.017	0.044	0.001
	2	0.072	4	350	538	0.009	0.033	1.4	0.0055	0.03	<0.0005
	3 *	0.353	90	310	470	0.022	NA	0.7	0.014	0.07	0.0025
	4 *	0.268	19	380	600	0.021	0.053	0.6	0.014	0.04	0.001
E-2	1	NA	7	480	680	0.016	0.03	1.5	0.006	0.044	0.001
	2	NA	3	410	620	0.014	0.029	1.4	0.006	0.038	0.0005
	3 *	NA	272	245	380	0.072	0.096	1.9	0.023	0.054	0.0045
	4 *	NA	34	365	635	0.03	0.041	1.2	0.011	0.047	0.001
W-6	1	0.08	17	270	470	0.01	0.032	0.7	0.0095	0.032	<0.0005
	2	0.08	25	285	455	0.011	0.072	1	0.0045	0.034	0.0005
	3 *	0.51	260	318	450	0.04	0.25	1.3	0.023	0.047	0.0075
	4 *	0.324	32	410	640	0.014	0.069	1.2	0.0075	0.047	0.0005
W-5(T)	1	0.025	<1	260	490	0.007	0.01	1.2	0.011	0.042	0.001
	2	0.023	2	290	475	0.009	0.025	1	0.011	0.034	0.0015
	3 *	0.194	400	210	310	0.107	0.36	2.5	0.058	0.054	0.016
	4 *	0.11	14	370	560	0.024	0.065	1.4	0.0055	0.044	0.001
W-10(T)	1	0.03	3	280	515	0.015	0.015	0.9	0.065	0.038	0.0005
	2	0.029	4	315	490	0.018	0.042	1.2	0.0085	0.032	0.0005
	3 *	0.167	205	270	370	0.078	0.24	2.2	0.024	0.038	0.0065
	4 *	0.188	8	350	520	0.042	0.08	0.9	0.014	0.038	<0.0005
W-15	1	0	11	265	425	0.014	0.014	1.2	0.004	0.036	0.0005
	2	0	3	295	430	0.016	0.054	1.7	0.0075	0.024	0.015
	3 *	0.012	13	280	410	0.014	0.021	1.6	0.022	0.025	0.0005
	4 *	0.023	4	290	448	0.009	0.039	0.2	0.018	0.05	0.001

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 2 (August 27-29 & September 4-5,1984)
(asterisks indicate wet weather days)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-17	1	220	140	56	76	48	0	3
	2	730	610	800	290	192	0	33
	3 *	7000	6000	9300	12500	9900	0	400
	4 *	4100	2700	730	490	270	10	36
	5	340	290	154	180	128	0	10
H-18	1	250	180	104	56	68	0	0
	2	820	680	328	368	116	0	2
	3 *	4000	3400	6200	10600	5500	0	104
	4 *	3200	1900	520	280	216	4	38
	5	480	340	158	170	66	0	13
H-19	1	230	210	92	64	24	0	4
	2	60	60	64	64	38	0	0
	3 *	11700	10900	17600	26800	27000	0	340
	4 *	1300	900	500	390	220	4	18
	5	500	500	224	240	108	0	7
H-11	1	270	190	176	112	96	0	8
	2	290	290	104	240	76	0	4
	3 *	16300	14900	14700	18800	24000	0	1600
	4 *	1350	1130	620	500	270	10	10
	5	330	330	152	170	144	8	2
H-10(T)	1	90	60	124	140	72	0	0
	2	110	100	192	560	116	0	1
	3 *	5300	5000	6000	9800	12000	0	6
	4 *	70	70	290	440	104	4	1
	5	80	80	88	160	92	2	0
H-9	1	130	60	216	192	108	0	4
	2	300	300	740	380	172	0	9
	3 *	4400	4100	2820	5800	5500	0	24
	4 *	1200	1000	770	610	270	20	7
	5	260	230	188	370	138	16	1
H-8	1	170	100	72	590	32	0	0
	2	190	190	140	360	104	0	0
	3 *	1800	1800	2340	2700	3000	0	2
	4 *	420	350	530	480	190	10	0
	5	220	220	96	250	82	0	0
H-6	1	140	70	100	240	180	0	0
	2	170	160	168	980	100	4	0
	3 *	2400	2100	1300	2400	4400	0	8
	4 *	840	730	670	570	280	30	0
	5	220	210	136	124	94	0	1
H-55(T)	1	100	100	16	20	112	0	0
	2	36	32	48	44	120	0	0
	3 *	300	300	80	40	92	0	0
	4 *	250	160	400	330	160	0	1
	5	250	210	160	112	56	0	0

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 2 (August 27-29 & September 4-5,1984)
(asterisks indicate wet weather days)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-2	1	1650	1530	430	1010	328	0	0
	2	5900	5300	2800	2200	408	32	11
	3 *	4300	3700	3300	6100	4000	0	2
	4 *	14600	12500	1100	630	1010	50	0
	5	3100	2500	930	490	440	32	0
H-20	1	160	90	1170	3300	3400	0	0
	2	230	210	3400	3500	580	10	0
	3 *	2900	2830	3300	6700	3900	0	1
	4 *	290	280	3000	570	720	10	2
	5	130	130	3020	470	198	2	0
E-8	1	430	370	276	340	284	0	6
	2	1070	980	2000	1370	960	4	12
	3 *	1100	1100	2960	6600	8500	0	32
	4 *	4500	4100	810	168	184	0	4
	5	900	900	302	204	108	12	1
E-9	1	140	120	60	108	60	0	0
	2	40	40	120	2700	50	0	0
	3 *	3800	3400	11900	12200	10600	0	40
	4 *	170	120	240	112	112	0	4
	5	130	120	88	148	54	0	3
E-6	1	110	80	196	104	132	0	0
	2	40	40	260	284	228	4	1
	3 *	2600	2400	17600	8100	16600	0	8
	4 *	190	160	244	92	136	4	0
	5	430	340	156	192	90	0	2
E-4	1	320	230	180	212	220	0	0
	2	140	120	1600	2600	880	0	0
	3 *	6400	6300	12100	21500	7800	0	172
	4 *	820	560	400	156	288	24	4
	5	270	240	248	252	212	32	9
E-2	1	240	190	200	112	176	0	0
	2	190	190	470	316	236	0	0
	3 *	23500	23200	29800	32600	30000	0	410
	4 *	3100	1500	1710	630	1770	20	16
	5	510	280	500	1400	580	22	8
W-6	1	130	100	60	68	80	0	0
	2	180	170	720	690	668	40	1
	3 *	9600	8900	22000	21100	19800	0	490
	4 *	700	470	570	690	340	10	8
	5	1000	800	324	310	162	0	3
W-5(T)	1	320	310	328	156	144	0	0
	2	400	400	530	456	476	0	0
	3 *	16800	15200	30000	34200	41000	0	690
	4 *	970	890	710	320	310	0	3
	5	1100	1000	276	280	228	4	2

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 2 (August 27-29 & September 4-5,1984)
(asterisks indicate wet weather days)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
W-10(T)	1	580	570	520	1080	1500	0	2
	2	270	270	280	280	240	0	3
	3 *	13600	13300	23000	36600	37000	0	300
	4 *	1040	890	1030	390	600	10	18
	5	600	600	376	352	258	6	0
W-3	1	60	60	124	76	124	0	0
	2	120	100	1200	1280	1360	0	0
	3 *	13000	11700	38600	32700	30000	0	2900
	4 *	1200	940	860	380	450	20	10
	5	1500	1300	360	592	192	0	1
W-2	1	1800	1770	3200	4100	3000	0	0
	2	1520	1510	2400	3000	2600	400	0
	3 *	10500	9500	11400	21500	5800	0	60
	4 *	650	560	500	228	292	56	6
	5	1200	1200	498	532	418	0	1

DRY EVENT 3

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - DRY EVENT 3 (December 10-12,1984)

STATION	DAY	Q (cms)	TSS (mg/l)	TDS (mg/l)	COND (umhos /cm2)	OP (mg/l)	TP (mg/l)	BOD (mg/l)	Cu (mg/l)	Pb (mg/l)	Cd (mg/l)
H-17	1	2.29	10.52	364	605	0.0065	0.015	0.59	0.002	<0.003	<0.0002
	2	2.47	10.58	400	630	0.0065	0.016	1.08	0.002	<0.003	<0.0002
	3	2.32	8.756	360	605	0.005	0.021	1.79	0.001	<0.003	<0.0002
H-15	1	1.64	26.14	330	540	0.007	0.034	0.86	0.002	<0.003	<0.0002
	2	1.92	9.44	336	555	0.0105	0.026	1.24	0.003	<0.003	<0.0002
	3	1.73	14.47	318	530	0.009	0.033	0.93	0.001	<0.003	<0.0002
H-14	1	1.77	40.72	336	542	0.0185	0.052	0.92	0.003	<0.003	<0.0002
	2	1.72	10.84	344	555	0.016	0.031	1.23	0.002	<0.003	<0.0002
	3	1.79	26.59	318	542	0.0195	0.053	1.46	0.002	<0.003	<0.0002
H-11	1	2.08	11.73	324	540	0.012	0.024	0.61	0.002	<0.003	<0.0002
	2	2.26	8.52	352	545	0.0135	0.026	1.09	0.002	<0.003	<0.0002
	3	1.31	9.252	322	535	0.01	0.026	1.17	0.002	<0.003	<0.0002
H-10(T)	1	0.298	3.592	296	515	0.008	0.009	0.41	0.001	<0.003	<0.0002
	2	0.302	3.092	330	515	0.008	0.009	0.79	0.001	<0.003	<0.0002
	3	0.305	4.068	316	520	0.007	0.016	0.92	0.001	<0.003	<0.0002
H-9	1	1.2	6.352	324	562	0.04	0.05	0.73	0.001	<0.003	<0.0002
	2	1.17	7.064	364	565	0.036	0.049	1.21	0.002	<0.003	<0.0002
	3	1.35	8.264	318	540	0.026	0.045	1.43	0.001	<0.003	<0.0002
H-75	1	1.73	16.23	306	510	0.004	0.022	0.74	0.003	<0.003	<0.0002
	2	1.83	7.529	328	515	0.005	0.015	1.28	0.002	<0.003	<0.0002
	3	1.78	18.18	306	505	0.001	0.037	1.07	0.002	<0.003	<0.0002
H-6	1	1.19	2.288	314	515	0.0045	0.012	0.68	0.001	<0.003	<0.0002
	2	1.25	2.492	334	515	0.004	0.013	1.48	0.001	<0.003	<0.0002
	3	1.32	2.464	306	515	0.004	0.014	1.07	0.001	<0.003	<0.0002
H-55(T)	1	0.28	2.372	316	505	0.0055	0.013	1.01	0.002	<0.003	<0.0002
	2	0.297	2.62	346	510	0.005	0.011	1.43	0.001	<0.003	<0.0002
	3	0.316	2.624	310	515	0.0055	0.017	1.04	0.003	<0.003	<0.0002
H-4(T)	1	0.277	3.176	306	505	0.0055	0.01	1.2	0.002	<0.003	<0.0002
	2	0.264	2.108	332	510	0.005	0.007	1.09	0.002	<0.003	<0.0002
	3	0.266	2.831	308	510	0.005	0.015	0.57	0.001	<0.003	<0.0002
E-8	1	0.883	4.816	420	755	0.003	0.006	0.6	0.002	<0.003	<0.0002
	2	1	5.34	452	735	0.003	0.009	1.4	0.002	<0.003	<0.0002
	3	0.874	5.236	416	730	0.002	0.012	1.51	0.002	<0.003	<0.0002
E-7(T)	1	0.099	3.848	378	670	0.002	0.002	0.37	0.002	<0.003	<0.0002
	2	0.101	5.348	406	685	0.0025	0.006	1.86	0.002	<0.003	<0.0002
	3	0.109	4.808	394	700	0.0025	0.007	0.81	0.001	<0.003	<0.0002
E-6	1	0.358	4.292	424	745	0.004	0.009	0.62	0.001	<0.003	<0.0002
	2	0.556	4.492	444	710	0.0045	0.008	0.91	0.002	<0.003	<0.0002
	3	0.364	3.904	414	720	0.003	0.013	1.21	0.002	<0.003	<0.0002
E-4	1	0.26	3.644	412	701	0.0085	0.015	0.61	0.002	<0.003	<0.0002
	2	0.268	2.136	442	700	0.008	0.014	1.11	0.002	<0.003	<0.0002
	3	0.268	2.916	424	725	0.008	0.018	1.3	0.002	<0.003	<0.0002
E-2	1	NA	6.156	456	801	0.0125	0.027	0.83	0.002	<0.003	<0.0002
	2	NA	6.844	492	807	0.0245	0.033	1.05	0.003	<0.003	<0.0002
	3	NA	5.48	450	770	0.015	0.036	1.29	0.002	<0.003	<0.0002
W-6	1	0.231	3.576	458	775	0.0025	0.006	1.07	NA	NA	NA
	2	0.284	5.016	478	770	0.003	0.013	2.04	0.003	<0.003	<0.0002
	3	0.257	4.384	462	775	0.003	0.011	1.09	0.003	0.005	<0.0002

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - DRY EVENT 3 (December 10-12,1984)

STATION	DAY	Q (cms)	TSS (mg/l)	TDS (mg/l)	COND (umhos /cm2)	OP (mg/l)	TP (mg/l)	BOD (mg/l)	Cu (mg/l)	Pb (mg/l)	Cd (mg/l)
W-5(T)	1	0.087	1.76	386	640	0.002	0.006	0.83	0.004	<0.003	<0.0002
	2	0.09	1.788	400	637	0.0025	0.007	1.49	0.002	<0.003	<0.0002
	3	0.093	1.624	386	630	0.002	0.009	1.16	0.003	0.006	<0.0002
W-10(T)	1	0.196	3.718	364	590	0.003	0.006	1.32	0.002	<0.003	<0.0002
	2	0.204	2.028	384	600	0.0035	0.014	3.7	0.002	<0.003	<0.0002
	3	0.222	3.764	370	605	0.0025	0.017	3.22	0.002	<0.003	<0.0002
W-15	1	0.019	3.972	510	795	0.007	0.015	0.69	0.003	<0.003	<0.0002
	2	0.022	3.428	526	800	0.006	0.015	1.5	0.003	<0.003	<0.0002
	3	0.025	3.676	478	760	0.006	0.015	1.14	0.003	0.004	<0.0002

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 3 (December 10-13,1984)
(asterisks indicate wet weather days)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-17	1	50	50	60	30	NA	NA	<4
	2	160	160	180	170	NA	NA	<4
	3	70	70	30	50	NA	NA	<2
	4 *	240	240	140	160	NA	NA	<4
H-18	1	270	270	70	60	NA	NA	<4
	2	140	140	190	380	NA	NA	<4
	3	380	360	60	180	NA	NA	2
	4 *	80	90	60	180	NA	NA	<4
H-19	1	60	60	50	60	NA	NA	<4
	2	30	30	40	20	NA	NA	<4
	3	10	10	10	10	NA	NA	<2
	4 *	60	60	60	220	NA	NA	<4
H-11	1	190	180	120	20	NA	NA	<4
	2	90	80	10	50	NA	NA	<4
	3	180	180	40	90	NA	NA	<2
	4 *	1600	1400	2000	1200	NA	NA	<10
H-10(T)	1	60	60	20	10	NA	NA	<4
	2	30	30	20	20	NA	NA	<4
	3	40	40	50	10	NA	NA	<2
	4 *	220	210	750	890	NA	NA	<4
H-9	1	180	180	120	70	NA	NA	<4
	2	310	300	190	30	NA	NA	<4
	3	190	180	170	110	NA	NA	<2
	4 *	1400	140	>3000	2860	NA	NA	4
H-8	1	10	10	90	10	NA	NA	<4
	2	10	10	60	10	NA	NA	<4
	3	20	20	40	20	NA	NA	<2
	4 *	1060	240	860	940	NA	NA	4
H-6	1	30	30	10	<10	NA	NA	<4
	2	50	50	10	20	NA	NA	<4
	3	50	50	30	40	NA	NA	<2
	4 *	340	320	270	390	NA	NA	<4
H-55(T)	1	30	30	30	40	NA	NA	<4
	2	<10	<10	50	10	NA	NA	<4
	3	20	20	10	20	NA	NA	<2
	4 *	330	280	310	350	NA	NA	4
H-2	1	2800	2600	340	130	NA	NA	8
	2	200	200	20	80	NA	NA	<4
	3	470	420	50	120	NA	NA	8
	4 *	240	240	120	130	NA	NA	<4
H-20	1	10	10	40	90	NA	NA	<4
	2	20	20	10	110	NA	NA	<4
	3	30	30	30	50	NA	NA	<2
	4 *	110	110	180	290	NA	NA	<4

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - DRY EVENT 3 (December 10-13,1984)
(asterisks indicate wet weather days)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	DAY	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
E-8	1	940	930	100	70	NA	NA	4
	2	160	130	310	290	NA	NA	<4
	3	1790	1780	110	160	NA	NA	<2
	4 *	1610	1010	110	290	NA	NA	4
E-9	1	10	10	90	30	NA	NA	<4
	2	<10	<10	60	50	NA	NA	<4
	3	20	20	30	10	NA	NA	<2
	4 *	10	10	70	80	NA	NA	<4
E-6	1	<10	<10	60	<10	NA	NA	<4
	2	10	10	10	20	NA	NA	<4
	3	30	30	10	<10	NA	NA	<2
	4 *	10	10	30	110	NA	NA	<4
E-4	1	90	90	10	50	NA	NA	4
	2	100	90	10	20	NA	NA	<4
	3	100	100	30	20	NA	NA	<2
	4 *	260	250	270	330	NA	NA	<4
E-2	1	520	470	30	180	NA	NA	4
	2	470	420	30	40	NA	NA	4
	3	470	440	90	50	NA	NA	4
	4 *	2340	2220	2120	2160	NA	NA	4
W-6	1	30	30	20	<10	NA	NA	4
	2	20	20	10	40	NA	NA	<4
	3	20	20	20	10	NA	NA	<2
	4 *	160	160	140	60	NA	NA	<4
W-5(T)	1	10	10	20	20	NA	NA	<4
	2	<10	<10	20	20	NA	NA	<4
	3	50	50	<10	40	NA	NA	<2
	4 *	70	70	150	190	NA	NA	4
W-10(T)	1	100	100	100	130	NA	NA	<4
	2	30	30	70	150	NA	NA	<4
	3	80	80	40	110	NA	NA	<2
	4 *	370	350	330	450	NA	NA	<4
W-3	1	20	20	30	30	NA	NA	<4
	2	30	30	20	20	NA	NA	<4
	3	80	80	<10	10	NA	NA	<2
	4 *	90	80	140	150	NA	NA	<4
W-2	1	<10	<10	10	10	NA	NA	<4
	2	20	<10	<10	20	NA	NA	<4
	3	<10	<10	40	20	NA	NA	<2
	4 *	560	440	660	780	NA	NA	20

WET EVENT

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - WET EVENT (November 11-13,1984)
(a "C" indicates a composite sample)

STATION	SAMPLE NUMBER	DATE	TIME	Q cms	TSS mg/l	TDS mg/l	COND umhos /cm2	OP mg/l	TP mg/l	BOD mg/l	Cu mg/l	Pb mg/l	Cd mg/l
H-17	1	11/11/84	09:55	11.04	355	290	570	0.54	0.57	<0.5	0.023	0.05	0.006
	2	11/11/84	12:00	11.68	230	330	670	0.28	0.35	1	0.015	0.034	0.0045
	4	11/11/84	14:55	11.45	170	300	600	0.2	0.26	1	0.01	0.037	0.005
	6	11/11/84	18:30	11.68	140	340	630	0.16	0.22	1	0.0085	0.031	0.004
	8	11/11/84	22:25	12.61	210	320	650	0.16	0.28	3	0.0095	0.037	0.0055
	9	12/11/84	18:40	10.23	86	310	630	0.13	0.2	1	0.009	0.027	0.0045
	10	13/11/84	11:20	6.92	44	300	640	0.06	0.08	<0.5	0.007	0.025	0.003
H-15	1	11/11/84	10:15	3.67	112	270	570	0.13	0.2	1	0.008	0.022	0.0025
	3	11/11/84	13:45	4.42	92	270	590	0.09	0.13	<0.5	0.01	0.024	0.0025
	5	11/11/84	16:55	4.62	134	280	610	0.1	0.16	<0.5	0.0065	0.028	0.0025
	6	11/11/84	19:45	5.11	188	260	580	0.14	0.21	2	0.0075	0.029	0.0035
	8	11/11/84	22:45	5.69	250	250	570	0.18	0.26	1	0.009	0.025	0.0025
	9	12/11/84	19:10	4.94	138	280	560	0.12	0.19	<0.5	0.014	0.028	0.003
	10	13/11/84	11:45	3.65	40	280	570	0.05	0.12	<0.5	0.013	0.017	0.001
H-14	6	11/11/84	16:20	4.69	130	290	570	0.07	0.25	3	0.0095	0.028	0.0025
	9	11/11/84	19:50	5.05	91	235	560	0.09	0.24	3	0.0215	0.036	0.0065
	13	11/11/84	23:50	5.77	240	280	580	0.2	0.33	1	0.023	0.04	0.006
	14	12/11/84	02:00	6.23	230	260	560	0.18	0.28	2	0.017	0.033	0.0045
	15	12/11/84	18:10	4.67	105	280	550	0.1	0.16	<0.5	0.03	0.024	0.0065
	16	13/12/84	12:30	3.55	34	280	570	0.05	0.07	<0.5	0.0055	0.0315	0.00125
H-11	1	11/11/84	10:58	4.27	139	240	550	0.08	0.16	2	0.018	0.032	0.0025
	3	11/11/84	14:05	5.14	200	280	580	0.15	0.24	3	0.0185	0.034	0.003
	6	11/11/84	18:35	5.94	230	270	570	0.15	0.29	5	0.0165	0.032	0.0045
	8	11/11/84	22:10	6.72	270	280	580	0.18	0.35	3	0.008	0.031	0.0032
	9	11/11/84	23:40	7.35	350	285	550	0.19	0.4	3	0.01	0.039	0.0045
	10	12/11/84	20:30	4.09	80	280	540	0.08	0.12	<0.5	0.007	0.02	0.0015
	11	13/11/84	13:55	3.39	22	280	570	0.04	0.06	<0.5	0.002	0.022	0.001
H-10(T)	C	11/11/84	-	-	74	260	560	0.05	0.08	8	0.0235	0.027	0.004
	C	12/11/84	-	-	10	320	580	0.03	0.06	<0.5	0.0095	0.028	0.0025
H-9	1	11/11/84	11:25	4.3	136	245	540	0.1	0.16	2	0.011	0.024	0.0025
	3	11/11/84	14:15	4.45	130	280	570	0.1	0.16	3	0.0135	0.028	0.0035
	4	11/11/84	15:50	5.04	200	260	570	0.12	0.23	4	0.013	0.027	0.0015
	5	11/11/84	17:25	5.38	220	250	550	0.15	0.27	1	0.013	0.033	0.003
	7	11/11/84	20:48	6.42	410	260	540	0.25	0.44	2	0.0115	0.045	0.005
	9	11/11/84	23:50	5.98	300	260	580	0.19	0.32	2	0.0085	0.037	0.005
	10	13/11/84	12:00	2.51	26	290	570	0.05	0.07	<0.5	0.0098	0.03	0.0019
H-75	1	11/11/84	10:15	4.5	86	270	540	0.06	0.12	1	0.0095	0.026	0.0025
	2	11/11/84	11:50	4.8	100	240	530	0.06	0.16	1	0.0085	0.022	0.001
	3	11/11/84	13:25	5.18	158	240	530	0.08	0.19	2	0.01	0.024	0.0035
	5	11/11/84	16:30	5.58	210	240	530	0.13	0.26	1	0.011	0.025	0.0075
	6	11/11/84	18:00	4.7	280	240	530	0.16	0.3	3	0.0125	0.035	0.0075
	9	11/11/84	22:45	4.4	230	260	540	0.16	0.3	1	0.006	0.03	0.0028
	10	13/11/84	12:25	2.52	10	290	570	0.02	0.04	<0.5	0.0025	0.013	0.001

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - WET EVENT (November 11-13,1984)
(a "C" indicates a composite sample)

STATION	SAMPLE NUMBER	DATE	TIME	Q cms	TSS mg/l	TDS mg/l	COND umhos /cm2	OP mg/l	TP mg/l	BOD mg/l	Cu mg/l	Pb mg/l	Cd mg/l
H-6	4	11/11/84	13:35	4.55	350	240	520	0.13	0.36	3	0.0185	0.029	0.0055
	7	11/11/84	16:35	4.91	330	240	570	0.155	0.4	2	0.016	0.026	0.0035
	10	11/11/84	19:35	4.79	240	240	520	0.13	0.36	2	0.013	0.036	0.003
	13	11/11/84	22:35	4.45	205	225	520	0.11	0.26	2	0.02625	0.031	0.00425
	14	12/11/84	01:30	4.04	138	260	500	0.09	0.22	2	0.009	0.029	0.0025
	15	13/11/84	13:05	2.02	5	240	520	0.015	0.03	1	0.006	0.023	0.002
H-55(T)	C	11/11/84	-	-	24	240	510	0.03	0.05	1	0.014	0.018	0.002
	10	13/11/84	13:20	0.592	2	260	520	0.02	0.03	<0.5	0.005	0.019	0.002
H-4(T)	C	11/11/84	-	-	102	240	520	0.07	0.15	2	0.0235	0.026	0.0025
	10	13/11/84	13:50	0.282	4	240	520	0.01	0.03	1	0.005	0.022	0.0015
E-8	1	11/11/84	10:50	2.92	170	300	660	0.32	0.24	5	0.0205	0.03	0.005
	6	11/11/84	15:50	2.7	110	310	700	0.13	0.16	4	0.0145	0.022	0.003
	16	11/11/84	23:15	3.11	210	350	740	0.14	0.24	4	0.0165	0.075	0.00525
	17	12/11/84	19:30	2.67	80	380	750	0.08	0.11	1	0.022	0.027	0.003
	18	13/11/84	12:15	2.23	24	350	730	0.04	0.06	2.5	0.013	0.027	0.003
E-7(T)	C	11/11/84	-	-	240	370	740	0.32	0.31	1	0.027	0.035	0.0065
	10	13/11/84	13:31	0.17	6	410	800	0.02	0.03	3	0.002	0.02	0.0025
E-6	1	11/11/84	10:30	0.674	28	340	720	0.03	0.03	<0.5	0.014	0.02	0.001
	3	11/11/84	13:33	0.94	68	370	720	0.06	0.09	<0.5	0.015	0.028	0.002
	4	11/11/84	15:05	1.05	112	360	700	0.11	0.14	1	0.0175	0.029	0.0025
	6	11/11/84	18:05	1.13	124	340	670	0.09	0.14	<0.5	0.013	0.028	0.0022
	7	11/11/84	20:15	1.26	191	340	750	0.14	0.2	<0.5	0.016	0.029	0.0045
	9	11/11/84	23:10	1.21	210	370	780	0.17	0.24	1	0.006	0.03	0.003
	10	13/11/84	13:19	0.844	18	320	760	0.06	0.07	<0.5	0.0025	0.024	0.002
E-4	1	11/11/84	10:15	1.04	88	380	750	0.06	0.13	2	0.0155	0.031	0.0035
	2	11/11/84	11:50	1.13	92	370	740	0.06	0.14	2	0.01375	0.03	0.00325
	4	11/11/84	14:50	1.22	126	320	750	0.105	0.185	1	0.0165	0.028	0.002
	7	11/11/84	19:55	1.4	106	360	700	0.1	0.16	2	0.0135	0.028	0.003
	9	11/11/84	22:55	1.4	96	350	700	0.105	0.17	2	0.0045	0.028	0.0035
	10	13/11/84	13:01	0.682	10	360	740	0.06	0.07	<0.5	0.002	0.021	<0.0005
W-6	1	11/11/84	10:47	4.16	290	350	710	0.4	0.46	1	0.0195	0.032	0.006
	2	11/11/84	12:28	4.82	240	390	690	0.33	0.4	3	0.0175	0.037	0.0065
	4	11/11/84	15:32	5.26	194	370	690	0.28	0.355	1	0.0145	0.032	0.003
	5	11/11/84	17:11	5.93	183	335	720	0.33	0.36	<0.5	0.014	0.033	0.0065
	6	11/11/84	18:39	6.16	164	350	680	0.29	0.32	<0.5	0.01225	0.0265	0.0045
	9	11/11/84	22:41	5.86	104	380	730	0.24	0.27	<0.5	0.0085	0.028	0.0055
	10	13/11/84	11:11	1.13	24	400	710	0.11	0.14	2	0.0055	0.018	0.003

UPPER HUMBER RIVER STUDY
CHEMICAL DATA - WET EVENT (November 11-13,1984)
(a "C" indicates a composite sample)

STATION	SAMPLE NUMBER	DATE	TIME	Q cms	TSS mg/l	TDS mg/l	COND umhos /cm2	OP mg/l	TP mg/l	BOD mg/l	Cu mg/l	Pb mg/l	Cd mg/l
W-5(T)	1	11/11/84	10:57	0.567	134	280	620	0.19	0.29	2	0.0125	0.024	0.005
	2	11/11/84	12:39	0.554	96	300	610	0.17	0.22	3	0.11	0.024	0.004
	4	11/11/84	15:43	0.538	68	300	650	0.22	0.3	4	0.105	0.026	0.002
	6	11/11/84	18:54	0.516	40	310	650	0.21	0.28	4	0.009	0.03	0.0035
	8	11/11/84	22:06	0.485	34	330	670	0.19	0.21	5	0.006	0.024	0.0025
	9	13/11/84	11:20	0.201	6	380	680	0.03	0.06	1	0.0035	0.024	0.002
W-10(T)	1	11/11/84	11:08	0.82	100	290	600	0.15	0.25	<0.5	0.0125	0.02	0.002
	2	11/11/84	12:49	0.826	68	290	600	0.12	0.19	1	0.011	0.026	0.004
	4	11/11/84	15:52	0.799	48	290	640	0.1	0.18	<0.5	0.0148	0.023	0.003
	6	11/11/84	19:13	0.781	40	340	700	0.08	0.16	3	0.0095	0.028	0.0035
	7	11/11/84	20:46	0.77	34	330	690	0.08	0.13	<0.5	0.006	0.026	0.0025
	9	13/11/84	11:29	0.467	2	330	630	0.02	0.03•	<0.5	0.0025	0.021	0.0025
W-15	1	11/11/84	10:12	1.109	82	380	760	0.15	0.2	5	0.0115	0.027	0.005
	3	11/11/84	13:30	1.263	82	380	770	0.16	0.18	5	0.0115	0.031	0.003
	8	11/11/84	21:20	1.094	116	360	630	0.3	0.31	5	0.0085	0.027	0.0035
	9	13/11/84	10:45	0.214	18	390	720	0.14	0.19	2	0.005	0.025	0.0025

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - WET EVENT (November 11-14,1984)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	SAMPLE NUMBER	DATE	TIME	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-17	1	11/11/84	09:55	3400	2960	1000	NA	NA	NA	30
	8	11/11/84	22:25	2400	1600	900	NA	NA	NA	0
	9	12/11/84	18:40	9400	7200	3500	NA	NA	NA	14
	10	13/11/84	11:20	1400	1220	1500	NA	NA	NA	6
	11	14/11/84	12:50	880	610	570	NA	NA	NA	6
H-18	1	11/11/84	10:05	2200	1100	1400	1900	810	80	52
	5	11/11/84	16:45	1100	720	720	1100	944	72	2
	8	11/11/84	22:35	1600	1240	460	930	768	60	0
	9	12/11/84	18:57	1900	1700	2300	14000	9000	1700	8
	10	13/11/84	11:33	1900	1500	1100	3200	3800	2300	3
	11	14/11/84	12:45	450	440	450	620	260	0	2
H-15	1	11/11/84	10:15	520	380	740	1100	780	72	7
	5	11/11/84	16:55	900	510	390	830	764	40	4
	8	11/11/84	22:45	2200	2060	660	1100	936	72	0
	9	12/11/84	19:10	1400	1260	950	5000	4600	1300	18
	10	13/11/84	11:45	1300	1010	1200	3000	1460	600	2
	11	14/11/84	12:30	90	80	190	160	60	10	0
H-11	1	11/11/84	10:58	2800	2580	1200	NA	NA	NA	10
	6	11/11/84	18:35	6300	5300	850	NA	NA	NA	3
	9	11/11/84	23:40	3500	3130	680	NA	NA	NA	0
	10	12/11/84	20:30	2100	1800	2100	NA	NA	NA	12
	11	13/11/84	13:55	490	440	470	NA	NA	NA	0
	12	14/11/84	10:55	170	140	140	NA	NA	NA	4
H-10(T)	1	11/11/84	11:15	1100	1000	1000	NA	NA	NA	15
	3	11/11/84	14:09	600	280	900	NA	NA	NA	2
	9	11/11/84	23:54	290	80	1000	NA	NA	NA	3
	10	13/11/84	11:45	2000	1700	840	NA	NA	NA	10
H-9	1	11/11/84	11:25	3300	3120	980	3400	2600	24	26
	5	11/11/84	17:25	3200	2210	880	2300	2720	24	0
	7	11/11/84	20:48	3700	2780	940	2300	2160	24	0
	9	11/11/84	23:50	3500	3230	670	2900	2160	36	0
	10	13/11/84	12:00	140	140	200	360	310	120	6
	11	14/11/84	12:00	90	80	80	260	150	10	0
H-75	1	11/11/84	10:15	1400	1260	760	2900	1200	32	22
	5	11/11/84	16:30	3700	3610	680	1600	1472	28	0
	9	11/11/84	22:45	1800	1520	730	1500	812	48	0
	10	13/11/84	12:25	280	230	130	4000	330	200	0
	11	14/11/84	12:10	80	40	80	1500	360	5	0

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - WET EVENT (November 11-14,1984)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	SAMPLE NUMBER	DATE	TIME	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
H-6	1	11/11/84	10:35	640	580	560	NA	NA	NA	0
	5	11/11/84	16:45	940	900	570	NA	NA	NA	2
	9	11/11/84	23:00	630	460	700	NA	NA	NA	1
	10	13/11/84	12:45	250	210	80	NA	NA	NA	6
H-55(T)	1	11/11/84	10:45	350	200	720	1200	530	52	0
	4	11/11/84	15:18	360	170	580	1000	596	56	0
	7	11/11/84	20:15	570	470	730	970	412	52	2
	9	11/11/84	23:20	340	340	790	760	588	60	0
	10	13/11/84	13:20	110	80	130	160	60	0	4
E-8	1	11/11/84	10:50	3400	3100	1500	NA	NA	NA	36
	8	11/11/84	23:15	1500	850	780	NA	NA	NA	3
	9	12/11/84	19:30	4800	4200	4100	NA	NA	NA	6
	10	13/11/84	12:15	2300	2200	1200	NA	NA	NA	6
	11	14/11/84	12:20	4700	4600	1340	NA	NA	NA	6
E-9	1	11/11/84	10:35	2000	1960	1900	2200	580	84	4
	8	11/11/84	23:05	1000	770	740	1500	1604	60	4
	9	12/11/84	19:50	2300	2200	3000	24000	17000	2000	8
	10	13/11/84	12:00	1250	1060	1900	4900	5200	100	12
	11	14/11/84	12:10	1000	660	1200	2000	1060	10	5
E-7(T)	1	11/11/84	10:43	2200	2130	950	NA	NA	NA	12
	5	11/11/84	16:45	7500	7360	1700	NA	NA	NA	6
	9	11/11/84	23:20	6600	6540	1400	NA	NA	NA	10
	10	13/11/84	13:31	3400	2600	4300	NA	NA	NA	8
E-6	1	11/11/84	10:30	410	370	580	NA	NA	NA	<2
	4	11/11/84	15:05	340	300	430	NA	NA	NA	3
	7	11/11/84	20:15	1500	1380	610	NA	NA	NA	4
	9	11/11/84	23:10	2500	2370	1100	NA	NA	NA	4
	10	13/11/84	13:19	6500	4800	4900	NA	NA	NA	16
E-4	1	11/11/84	10:15	1380	1300	910	NA	NA	NA	14
	4	11/11/84	14:50	3500	2720	820	NA	NA	NA	1
	9	11/11/84	22:55	5000	4580	1200	NA	NA	NA	5
	10	13/11/84	13:01	4000	3200	2800	NA	NA	NA	2
E-2	1	11/11/84	10:00	4800	4570	1700	NA	NA	NA	11
	3	11/11/84	13:05	6000	5410	1600	NA	NA	NA	10
	9	11/11/84	22:40	8000	7830	1800	NA	NA	NA	3
	10	13/11/84	12:50	2900	2200	760	NA	NA	NA	10

UPPER HUMBER RIVER STUDY
MICROBIOLOGICAL DATA - WET EVENT (November 11-14,1984)

*** VALUES LISTED AS COUNTS/100mL ***

STATION	SAMPLE NUMBER	DATE	TIME	FC	EC	FS (M-ENT)	FS (M-E)	FS (K-F)	KF (Starch+)	PA
W-6	1	11/11/84	10:47	7700	7430	1400	NA	NA	NA	10
	6	11/11/84	18:39	800	730	2000	NA	NA	NA	16
	9	11/11/84	22:41	9000	8840	2700	NA	NA	NA	3
	10	13/11/84	11:11	19000	10100	11000	NA	NA	NA	70
	11	14/11/84	11:05	3100	2000	2700	NA	NA	NA	46
W-5(T)	1	11/11/84	10:57	9000	8860	1700	NA	NA	NA	6
	8	11/11/84	22:06	17000	16760	3000	NA	NA	NA	10
	9	13/11/84	11:20	5000	3300	3700	NA	NA	NA	66
	10	14/11/84	11:25	510	270	390	NA	NA	NA	12
W-10(T)	1	11/11/84	11:08	8800	2800	1400	NA	NA	NA	32
	8	11/11/84	22:18	11000	9940	3300	NA	NA	NA	11
	9	13/11/84	11:29	1300	1130	760	NA	NA	NA	20
	10	14/11/84	11:30	840	690	540	NA	NA	NA	6
W-3	1	11/11/84	10:30	3900	3860	2200	NA	NA	NA	11
	4	11/11/84	15:15	11000	10680	2600	NA	NA	NA	3
	8	11/11/84	21:32	19000	18400	3400	NA	NA	NA	29
	9	13/11/84	11:00	25000	16300	11000	NA	NA	NA	74
	10	14/11/84	10:45	3500	3400	6800	NA	NA	NA	30
W-2	1	11/11/84	10:22	2300	2230	1600	1400	1500	60	20
	3	11/11/84	13:39	3300	800	1500	2200	2360	24	16
	8	11/11/84	21:24	22000	19300	2500	2000	3400	16	2
	9	13/11/84	10:55	21000	16000	14000	26000	19500	2400	160
	10	14/11/84	10:35	4100	4000	1600	8600	6800	10	45

APPENDIX 3

EVENT SAMPLING : CORRELATIONS

Notes for Appendix 3

The variables used in the correlation analysis were the concentrations of the chemical parameters and corresponding instantaneous discharge values.

Abbreviation	Variable
Q	instantaneous discharge
TSS	total suspended solids
TDS	total dissolved solids
COND	conductivity
OP	orthophosphate
TP	total phosphorus
BOD	biochemical oxygen demand
Cu	copper
Pb	lead
Cd	cadmium

A "-" before a variable indicates that the stated correlation is negative.

Event Sampling : Significant ($p<0.05$) Correlations

Station	Dry Events	Wet Event
H-17	Q x TDS x COND TSS x Cu x Pb TDS x COND x -Pb OP x -BOD TP x Cu	TSS x OP x TP x Cu x Pb x Cd OP x TP x Cu x Pb TP x Cu x Pb x Cd Cu x Pb Cd Pb x Cd
H-15	Q x -TP TSS x -TDS x -COND x TP x Pb TDS x COND x -TP x -Pb TP x Cu x Pb Cu x Pb	Q x TSS x OP x TP TSS x OP x TP TDS x -BOD OP x BOD TP x BOD Pb x Cd
H-14	Q x TDS x -Pb TDS x -Pb COND x -Cu OP x -BOD	Q x TP TSS x TP Cu x Cd
H-11	Q x TDS TSS x -COND x TP x Cu x Pb TDS x COND x -TP x -Pb COND x -TP x -Cu x -Pb	Q x TSS x OP x TP x BOD x Cd TSS x OP x TP x BOD x Cd OP x TP x Cd

Event Sampling : Significant ($p<0.05$) Correlations

Station	Dry Events	Wet Event
H-11	TP x Pb	TP x BOD x Cd BOD x Cd
H-10(T)	Q x COND x -Pb TSS x TP x Cu TDS x -Pb COND x -OP x -Cu x -Pb OP x TP x Cu x Pb TP x Cu	Composite samples taken - no correlations available
H-9	Q x -Cu TSS x -TDS x -COND x Cu x Pb TDS x -Pb TP x Cu Cu x Pb	Q x TSS x OP x TP TSS x OP x TP OP x TP
H-75	Q x COND COND x -Pb OP x Cu Cu x Pb	Q x -TDS x -COND TSS x OP x TP x Pb TDS x COND OP x TP x Pb BOD x Cu Cu x Cd
H-6	Q x TDS x COND x -Pb TSS x -COND x TP	Q x OP x TP TSS x OP x TP OP x TP

Event Sampling : Significant ($p<0.05$) Correlations

Station	Dry Events	Wet Event
H-6	TSS x Cu	Cu x Cd
	x Pb	
	TDS x COND	
	x -Pb	
	COND x -TP	
	x -Pb	
	OP x TP	
	x Cu	
	TP x Cu	
	Cu x Pb	
H-55(T)	Q x COND	Composite samples taken - no correlations available
	x -OP	
	x -TP	
	TSS x -TDS	
	x OP	
	x TP	
	x Pb	
	TDS x -OP	
	x -Pb	
	COND x -TP	
	x -Cu	
	x -Pb	
	OP x TP	
	x Cu	
	Cu x Pb	
H-4(T)	Q x COND	Composite samples taken - no correlations available
	x -OP	
	x -Pb	
	TSS x -TDS	
	COND x -OP	
	x -TP	
	x -Cu	
	x -Pb	
	OP x TP	
	x Cu	
	x Pb	
	TP x Cu	
E-8	Q x TDS	Q x TSS
	x COND	
	x -Pb	

Event Sampling : Significant (p<0.05) Correlations

Station	Dry Events	Wet Event
E-8	TDS x COND x -Pb COND x -Pb OP x TP x Cu TP x Cu	
E-7(T)	Q x COND x -Cu TSS x OP x TP TDS x COND x -Pb COND x -Pb OP x TP x Cu Cu x Pb	Composite samples taken - no correlations available
E-6	Q x -Cu x -Pb TSS x -TDS x -COND TSS x OP x TP TDS x COND x -OP x -TP COND x -OP x -TP OP x TP Cu x Pb	Q x TSS x OP x TP x Pb Q x Cd TSS x OP x TP x Pb x Cd OP x TP X Pb x Cd TP x Pb x Cd Pb x Cd
E-4	TSS x -TDS x OP x TP x BOD x Cu TDS x -OP x -Cu x -Pb	TSS x TP OP x TP

Event Sampling : Significant (p<0.05) Correlations

Station	Dry Events	Wet Event
E-4	COND x -Pb OP x TP x BOD x Cu TP x BOD Cu x Pb	
E-2	TSS x OP x TP TDS x COND COND x -Cu OP x TP BOD x Cu x Pb Cu x Pb	No samples taken
W-6	Q x TDS x -Pb TSS x -COND x OP x TP COND x -OP x -TP x BOD x -Cu OP x TP x -BOD x Cu BOD x -Cu	Q x -BOD TSS x OP x TP x Cu OP x TP x Cu TP x Cu x Pb Pb x Cd
W-5(T)	Q x -TSS x COND x -OP x -TP x BOD x -Cu TSS x -COND x OP TSS x TP x -BOD TDS x -Cu x -Pb	Q x TSS x -TDS x -COND TSS x -TDS x -COND COND x -Cu

Event Sampling : Significant ($p<0.05$) Correlations

Station	Dry Events	Wet Event
W-5(T)	COND x -OP x -TP x -Cu OP x TP x Cu TP x Cu	
W-10(T)	Q x COND x -OP TSS x -COND x TP TDS x -Cu x -Pb COND x -OP x -TP x BOD OP x TP x -BOD TP x -BOD BOD x -Cu Cu x Pb	Q x TSS x OP x TP TSS x OP OP x TP
W-15	Q x -OP x -Pb TDS x COND x -Pb COND x -Cu	No significant correlations

APPENDIX 4

BED SEDIMENT DATA

UPPER HUMBER RIVER STUDY
BED SEDIMENT DATA (Samples collected November 28 - December 3,1984)

						*** GRAIN SIZE - PERCENTAGE COMPOSITION ***							
STATION	TP (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)	CLAY	SILT	VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	VERY COARSE SAND	LOSS ON IGNITION
H-17	62.5	20	20	<1	64	0.3	1.6	72.3	18.7	3.1	0	0	4
H-15	100	16	13	<1	51	0.2	1.5	33.8	18.2	16.4	12	5.2	3.4
H-14	525	19	16	<1	50	0.2	1.4	77.9	7.7	7.8	0.8	0	4
H-11	25	6	9.5	<1	30.5	0.2	0.8	46.4	11	22.6	5.2	1.5	2.1
H-10(T)	150	14	13	<1	52	0.2	1.3	66.2	15.8	8.4	3.4	0	4.7
H-9	375	14	25	<1	68	0.2	1.5	69.8	16.1	6.3	1.8	0	4.3
H-75	175	9	8.5	<1	42.5	0.1	1.2	77.5	8.7	4.9	1.7	0	5.5
H-6	275	12	6	<1	57	0.4	0.6	56	19.5	9	0.5	0	12.7
H-55(T)	525	15	11	<1	68	0.1	0.8	72.6	19.7	7.5	0.3	0.5	10.1
H-4(T)	250	12	9	<1	57	0.1	1.3	60.8	14.2	7.1	2	0.4	13.6
E-8	300	23.5	39.5	<1	104	0.2	1.4	76.1	13.9	2.7	0.5	0	4.7
E-7(T)	100	18	13	<1	53	0.2	1.1	54.5	14.8	9.4	11.2	0.6	4.3
E-6	75	16	9	<1	49	0.3	1.1	49	20.7	13.1	9.7	0.7	4.6
E-4	87.5	6	4	<1	30	0.1	0.6	28.8	16.3	23.8	27.3	0.7	2.6
E-2	250	20	25	<1	104	0.4	1.5	59.1	13.8	9.7	7.6	0	7.5
W-6	75	34	16	<1	82	0.2	1.8	59.5	9	5.6	13.4	0	5.2
W-5(T)	125	17	9	<1	35	0.1	0.3	8.8	53	16.3	29.8	15.8	4.6
W-10(T)	850	38	48	<1	99	0.1	1.1	65.4	12.8	7.8	2.4	0	9
W-15	325	17	16.5	<1	62	0.2	1.8	67.8	13.1	5.9	1.8	0	8

Matrix of Spearman Correlation Coefficients for Bed Sediment Chemistry and Grain Size Results.

	Clay	Silt	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse Sand	Total Phosphorus	Copper	Lead	Zinc
Silt (>0.03 <0.06 mm)	.370										
Very Fine Sand (>0.06 <0.13 mm)	-.043	.473									
Fine Sand (>0.13 <0.25 mm)	.107	-.399	-.423								
Medium Sand (>0.25 <0.50 mm)	.018	-.572	-.830	.326							
Coarse Sand (>0.50 <1.00 mm)	-.158	-.182	-.810	.084	.667						
Very Coarse Sand (>1.00 <2.00 mm)	-.290	-.544	-.743	.482	.733	.593					
Total Phosphorus	-.243	.043	.569	-.184	-.343	-.497	-.475				
Copper	.230	.480	.236	-.192	-.370	-.030	-.369	.197			
Lead	.249	.663	.442	-.341	-.460	-.248	-.540	.375	.769		
Zinc	.249	.527	.444	-.143	-.593	-.392	-.629	.474	.660	.768	
Loss on Ignition	-.123	-.001	.296	-.037	-.410	-.340	-.429	.556	.121	.026	.527

Note: With 19 observations a correlation coefficient of .456 is significant at $p=0.05$.
Cadmium was excluded from the correlation analysis because all values were < 1 mg/kg.

APPENDIX 5

FIELD INVENTORY AND SOIL LOSS MAPPING DATA

Area (ha) of High Overland Sediment Delivery Potential Within Each Subbasin

Subbasin	Area of High Delivery (ha)	% of Subbasin Area
H-17	191	4
H-18	0	0
H-15	0	0
H-19	97	14
H-14	188	14
H-11	442	26
H-9	34	5
H-8	56	14
H-75	400	13
H-10(T)	1,210	19
H-6	116	7
H-55(T)	494	11
H-4(T)	448	19
H-2	283	8
H-20	244	9
E-8	7	1
E-9	89	7
E-7(T)	430	12
E-6	1,021	22
E-4	554	18
E-2	399	6
W-6	228	6
W-5(T)	236	6
W-10(T)	95	4
W-3	97	8
W-2	0	0
W-15	207	6

Field Inventory Results: Erosive Area of Stream Bank and Livestock Access

Subbasin	Watercourse Length (km)	Erosive Area of Stream Bank (m^2)	Length subject to Livestock Access (km)
H-17	2.40	1869	0.00
H-18	2.92	1681	0.00
H-15	0.60	101	0.00
H-19	5.88	16015	3.90
H-14	15.45	29684	0.00
H-11	10.45	13042	2.00
H-9	3.40	827	0.00
H-8	5.20	3883	0.00
H-75	12.58	7221	0.01
H-6	8.27	1590	0.15
H-55(T)	15.05	6484	0.50
H-4(T)	8.55	6370	0.90
H-2	5.85	1987	0.60
H-20	9.55	452	0.73
E-8	2.95	2486	0.00
E-9	11.62	15978	0.00
E-7(T)	11.90	15322	1.90
E-6	17.98	28482	2.00
E-4	10.40	14855	2.80
E-2	12.35	9494	1.10
W-6	9.70	17740	4.85
W-5(T)	2.45	5264	1.80
W-10(T)	17.99	3593	6.75
W-3	4.75	7783	2.45
W-2	2.18	4028	0.15
W-15	13.10	14630	3.35

Point Source Sampling

A two-day antecedent dry period was allowed before water samples were collected from point sources. Between November 7 and December 5, 1984, one sample was collected from each selected inflow and analysed by the Laboratory Services and Applied Research Branch of the MOE for the following:

Parameter	Abbreviation Used
Fecal coliforms M-TEC	FC
Escherichia coli M-TEC	EC
Fecal streptococcus M-Enterococcus	FS M-ENT
Pseudomonas aeruginosa	PA
Total suspended solids	TSS
Total dissolved solids	TDS
Conductivity	COND
Biochemical Oxygen Demand	BOD
Total phosphorus	TP
Orthophosphate	OP
Copper	Cu
Lead	Pb
Cadmium	Cd

For each sample collected, a survey form was completed, an example of which is included here. Most sampled inflows were labelled either by spray painting them with an identification number or by marking them with a labelled wooden stake; inflows were also photographed.

A total of 26 samples were collected, three of which were not specifically inflows. A suspected problem existed in the vicinity of inflows H20-L-I01 and H20-R-I01. In addition to sampling these point sources, instream water samples were taken upstream and downstream of the area because it was suspected that general contaminant seepage might be occurring from the stream banks at this site. There was a heavy concentration of spring sources in one reach of subbasin W-10(T). Rather than sample all possible inflows, one instream water sample was taken immediately downstream of this area.

UPPER HUMBER RIVER STUDY - DRY WEATHER INFLOW SURVEY

Identification

Watercourse ____________________ Date ____________________

Unit ____________________ Time ____________________

Bank Side ____________________ Investigators ____________________

Inflow No. ____________________ ____________________

Sample

Weather - today ____________________

- yesterday ____________________

Sample No. ____________________

Submission No. ____________________

Water temperature ____________________

Conductivity ____________________

Inflow Description

Type ____________________

Label - Paint ____________________ Stake ____________________

Photograph No. ____________________

Flow rate ____________________

Water depth ____________________

Water width ____________________

Comments

UPPER HUMBER RIVER STUDY
POINT SOURCE INFLOW SAMPLING (November 7 - December 5,1984)

CODE	DESCRIPTION	DATE	TIME	WIDTH cm	DEPTH cm	FLOW *	FC /100ml	EC /100ml	FS(M-ENT) /100ml	PA /100ml	TSS mg/l	TDS mg/l	COND umhos /cm2	BOD mg/l	TP mg/l	DP mg/l	Cu mg/l	Pb mg/l	Cd mg/l
H01-R-104	storm sewer	07/11/84	13:45	38	8.5	T	15000	15000	24000	28	8.912	** NA	1660	NA	0.026	0.0175	0.006	0.013	<0.0002
H02-L-101	storm sewer	07/11/84	14:32	18	<1	M	2900	2900	910	8	0.548	NA	1540	NA	0.013	0.009	0.005	<0.003	<0.0002
H02-R-101	storm sewer	07/11/84	15:07	80	<1	T	31000	31000	7600	16	4.772	NA	1009	NA	0.031	0.0235	0.005	<0.003	<0.0002
H02-R-102	storm sewer	07/11/84	15:29	NA	NA	T	80	80	40	<4	6.452	NA	1410	NA	0.026	0.0075	0.006	<0.003	<0.0002
H02-R-103	storm sewer	07/11/84	15:44	20	<1	M	140	140	140	<4	20.13	NA	1262	NA	0.117	0.075	0.008	<0.003	<0.0002
H05-L-101	Kleinburg STP	08/11/84	11:28	17	<1	F	<20	<20	40	<4	10.15	NA	1850	NA	4.8	4.59	0.013	<0.003	<0.0002
H07-L-101	tributary	08/11/84	12:15	130	5	T	500	500	100	<4	1.26	NA	660	NA	0.017	0.0095	0.001	<0.003	<0.0002
H10-L-103	storm sewer	20/11/84	14:50	17	<1	F	3700	3700	5200	4	37.62	690	979	4.62	1.04	0.605	0.006	0.003	<0.0002
H10-L-105	storm sewer	20/11/84	15:10	10	<1	F	200000	180000	18000	<10	4.148	1468.4	2290	2.15	0.07	0.153	0.007	0.013	<0.0002
H10-R-102	Bolton STP	06/11/84	14:30	43	9	F	<20	<20	80	<4	1.904	NA	1530	NA	0.31	0.263	0.004	<0.003	<0.0002
H10-R-109	storm sewer	08/11/84	14:56	28	<1	M	100	100	300	<4	1.12	NA	771	NA	0.017	0.012	0.003	<0.003	<0.0002
H10-R-122	storm sewer	20/11/84	15:30	25	<1	F	3400	3300	3300	<4	20.33	1044.4	1420	1.41	0.015	0.004	0.005	<0.003	<0.0002
H20-L-101	drain pipe	22/11/84	11:05	17	5	F	<10	<10	<10	<4	1.476	294	480	1.86	0.011	0.0015	0.001	<0.003	<0.0002
H20-R-101	drain pipe	22/11/84	11:30	2	<1	M	<10	<10	<10	<4	1.012	258	440	0.41	0.003	0.0045	0.001	<0.003	<0.0002
H20 above	river	22/11/84	11:40	NA	NA	NA	40	40	30	<4	3.624	326	550	0.75	0.015	0.005	0.002	<0.003	<0.0002
H20 below	river	22/11/84	12:00	NA	NA	NA	2100	1600	110	4	8.012	324	551	1.01	0.03	0.004	0.002	<0.003	<0.0002
E01-L-102	storm sewer	20/11/84	11:00	45	1.5	M	210000	200000	2100000	772	6.063	764	1009	3.79	0.29	0.22	0.005	<0.003	<0.0002
E01-L-105	storm sewer	20/11/84	11:50	45	2.5	F	5600	5200	1900	120	569.5	786	1104	3.18	0.695	0.0345	0.02	0.013	<0.0002
E01-L-106	storm sewer	20/11/84	12:35	10	<1	F	1100	1000	27000	<10	15.04	1068.5	1470	4.56	0.02	<0.002	0.004	<0.003	<0.0002
E01-L-107	storm sewer	20/11/84	12:10	65	<1	M	1600	1500	4900	<10	15.62	928	1255	NA	<0.004	<0.002	0.005	<0.003	<0.0002
E01-R-108	storm sewer	20/11/84	13:30	32	1.5	F	3800	3300	820	16	2.468	902	1200	1.06	0.165	0.138	0.006	<0.003	<0.0002
E04-R-101	storm sewer	20/11/84	14:00	15	1	M	190	180	20	<4	0.724	908	1330	NA	0.37	0.352	0.006	<0.003	<0.0002
E10-R-102	drain pipe	05/12/84	10:00	17	2	F	40	40	<20	<10	7.1	416	700	2	0.03	0.04	0.18	0.01	<0.001
G05 below	river	22/11/84	14:10	NA	NA	NA	170	170	60	<4	5.556	402	622	2.73	0.023	0.007	0.002	<0.003	<0.0002
K05-R-102	drain pipe	05/12/84	10:50	25	2	T	25000	25000	16000	<20	53	550	625	5.3	0.86	0.74	0.01	<0.02	<0.005
A08-R-102	storm sewer	22/11/84	13:00	73	14	T	18000	17000	1380000	200	572.3	2940.5	6010	190	2.35	0.028	0.062	0.19	0.001

* T - trickle, M - moderate, F - fast
** no data available

Figure 3.17 Overland Sediment Delivery

AVAILABLE ON REQUEST

Figure 3.20 Locations of Point Source Inflows

AVAILABLE ON REQUEST

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